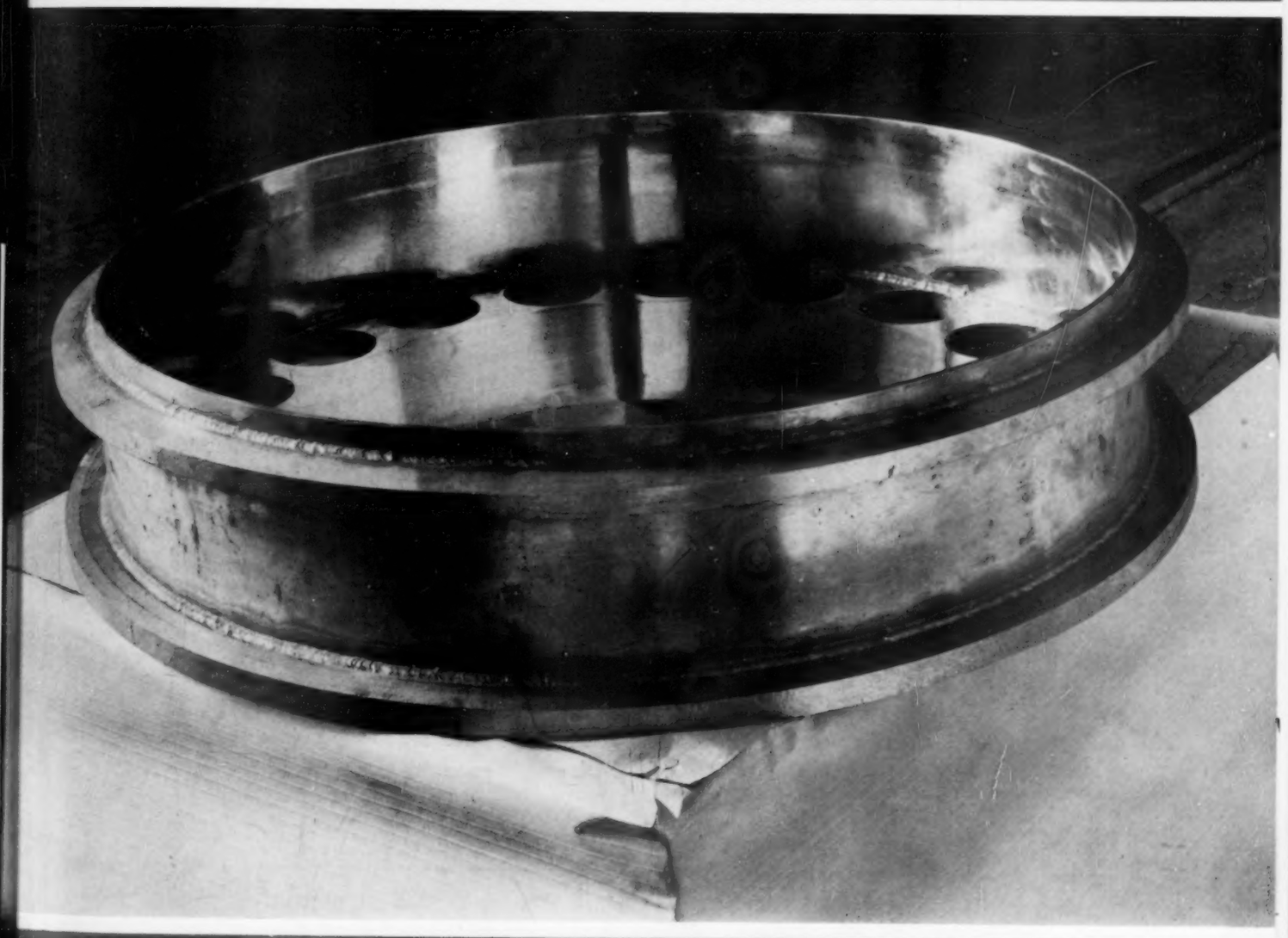
JULY 1940

# The WELDING Journal

JUL 11 1940



The Journal of the American Welding Society

# "WE'VE NEVER HAD A JOB THAT G-E RODS COULDN'T HANDLE"

NOW, more than ever before, the General Electric line of rods is ready to answer every deposition problem of speedy, dependable welding.

Approved by every major board of authority, our complete line provides a long-awaited source of supply for electrodes to handle ALL major work classifications.

From an operator's viewpoint, G-E heavily coated electrodes are mighty easy to use—special flux coatings help assure high-quality welds, with fewer rejects and less re-working. Gas escape is speedy and complete, allowing clean welds and easy removal of slag blanket and spatter.

G-E heavily coated electrodes produce sufficient "cupping effect" on the electrode to direct the arc to the working area in a sharp, highly concentrated manner that gives complete control and ease of working. You can do more work per day when your electrodes handle easily, work fast, and give ample penetration deep into each joint.

**No matter what your electrode problems are, they can be answered completely and satisfactorily by your nearest G-E arc-welding distributor or G-E sales office—or write General Electric Company, Schenectady, N. Y.**

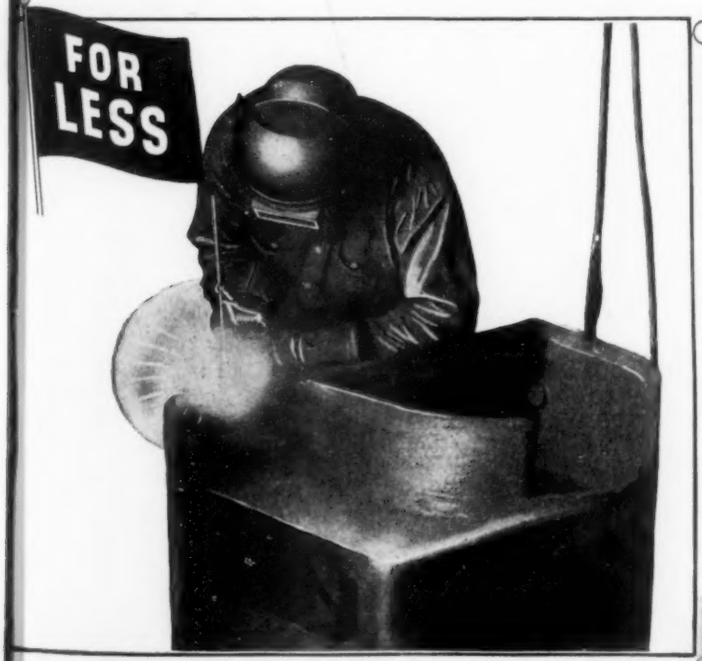
**GENERAL ELECTRIC**

140-85

# *new* Hobart Multi-Range will weld your work...

**MUCH FASTER** because there's no waiting for voltage to build up with a Hobart Welder. Dependable, inbuilt, 4-pole exciter generator insures against delays. Exceptional stabilization at all settings makes it easy to strike and maintain the arc on all types of work. Hobart speeds up production and does maintenance work much faster.

. . **MUCH BETTER** because the Remote Control, an exclusive Hobart feature, makes it possible for the operator to get the right setting without leaving his work. It eliminates the temptation to "get by" with improper arc adjustments. And with 1,000 combinations to select from, the operator gets EXACTLY the right welding heat without extra effort.




. **FOR MUCH LESS** per unit of time, footage or poundage. Because the Multi-Range Arc Welder will weld faster and gets better quality welds, you can easily see why welding with a Hobart costs less. Savings in labor and current costs; elimination of rejects; better welds . . . all spell MORE PROFIT FOR YOU! Get details on this today!

**THE HOBART BROTHERS CO., BOX WJ-740, TROY, OHIO**

**LET US PROVE IT IN YOUR SHOP, ON YOUR WORK, FOR 30 DAYS AT OUR RISK!**

**FREE!**

☐ "New Profits in Arc Welding"

☐ "New Hobart Arc Welding Catalog"

**HOBART BROS. CO., BOX WJ-740, TROY, OHIO**

Send complete information about the new Hobart Multi-Range Arc Welder, without obligation.

☐ Electric Drive ☐ Gas Drive ☐ "Build Your Own"

I'm interested in _____ amp. capacity.

To be used for _____

Details on ☐ 30 Days Trial ☐ Easy Terms ☐ Rental Term

NAME _____

ADDRESS _____ STATE _____

CITY _____

# The American Welding Society Journal

W. SPRARAGEN, Editor

Published for the Advancement of the Science and Art of Welding

OFFICERS—1939–1940
President, G. T. HORTON
First Vice-President, T. C. SMITH
Second Vice-Pres., L. S. MOISSEIFF
Treasurer, C. A. McCUNE
Secretary, M. M. KELLY
Technical Secretary, W. SPRARAGEN

VOLUME 19 NUMBER 7

JULY 1940

Divisional Vice-Presidents
W. F. HESS, New York & New England
L. C. BIBBER, Middle Eastern Division
K.L.HANSEN, Middle Western Division
L. W. DELHI, Pacific Coast
A. J. MOSES, Southern


# CONTENTS

## TECHNICAL PAPERS, ITEMS AND REPORTS


All-Welded Steel Underbridge at Hainault, by H. W. Clark 469
Repair of Mechanical Equipment by Welding, by W. M. Galloway 475
Welding in the Aircraft Industry, by L. P. Wood 476
Oxyacetylene Gouging—a Flame-Machining Process, by R. F. Flood 482
Machine Flame Cutting, by H. C. Boardman 487
The Smit-Unionmelt Welding Process 499
Flame-Cutting Clad Steel, by H. F. Lassner 500
Current Welding Literature 501
Welding Metallurgy, by O. H. Henry and G. E. Claussen 501
Welding for Enameling, by Joseph C. Lewis 509
Tentative Specifications for Iron and Steel Arc-Welding Electrodes 512


## SOCIETY AND RELATED ACTIVITIES


Mobilizing Engineering Talent 481
Coal Barge 508
A. W. S. Nominations for 1940 516
George Horton, New Chairman of Plan Group 516
Proposed Changes in By-Laws 516
A. S. M. E. Annual Meeting 516
A. S. M. E. Nominees 516
New General Electric Building 518
Chicago Bridge and Iron Company Changes 518
Stedman Joins Bastian-Blessing Company 518
Index to Advertisers 518
Communication to the Editor 520
Obituary—Capt. E. P. Jessop 520
Pipe Tee 520
Welded Steel Carfloats for New York Harbor 522
Evolution of Electric Washing Machine Shows Value of Industrial Progress 524
An Interesting Pamphlet 524
Swiss Acetylene Society 526
Purchasing Agent 526
E. H. Anchors 526
Metal Spraying 526
S. S. Exchequer 526
Brazing Alloys Leaflet 526
New Products 528
Section Activities 536
Employment Service Bulletin 538
Book 538
List of New Members 540
To Direct Research for Metal & Thermit Corp. 542
Obituary—Oscar B. McLaughlan 542
Crypt of Civilization Sealed for 6000 Years 542
Sections—Chairmen, Secretaries and Regular Meeting Dates 543


**COVER**

Head Ring for Cardboard Carton Milk Packaging Machine—18–8 Stainless Steel. *Courtesy Page Steel and Wire Company.*

## WELDING RESEARCH SUPPLEMENT


Resistance Welding Aluminum and Its Alloys, by W. Spraragen and G. E. Claussen 241-s



ISSUED MONTHLY



Copyright, 1940, by the American Welding Society



Subscription $5.00 per year in United States and possessions; $5.50 in Canada and Mexico; Foreign Countries $7.00. Single copies, non-members $.75; Special issues October and December $1.00; members 50 cents.

Entered as second-class matter January 15, 1932, at the post-office at Easton, Pa., under the Act of March 3, 1879.

PUBLICATION OFFICE
20th & Northampton Streets, Easton, Pa.

EDITORIAL AND GENERAL OFFICES
33 West 39th., New York, N. Y.



The Society is not responsible for any statement made or opinion expressed in its publications. Permission is given to reprint any article after its date of publication provided proper credit is given.

Welding Journal

VOLUME 19, No. 7 JULY 1940

# ALL-WELDED STEEL UNDERBRIDGE at Hainault

By H. W. CLARK, A.M.Inst.C.E., M.Inst.W., M.A.W.S.*

THE use of welding for railway plate girder bridge construction is an application which until recently has been sadly neglected in this country, although a great many notable examples have existed abroad for a considerable period of time and have established beyond all doubt the advantages which result from the use of arc welding for this type of work. For this reason the following description of the London Transport second new all-welded bridge recently erected at Hainault, Essex, is of special interest, not only from the purely technical point of view but also because this bridge is only the second of its kind ever built in Great Britain, and built—be it noted—by the same authority. Thus, although we have had a number of examples of the use of arc welding for railway bridge repairs and strengthening, the British welding industry owes a great debt to the London Passenger Transport Board for being the first authority in this country to adopt the process for the construction of new railway plate girder bridges.

* Indoor Assistant to Civil Engineer, London Passenger Transport Board.

The program of expansion which has recently been undertaken by London Transport has necessitated the building of a number of entirely new bridges and the replacement of some of the existing ones. The development and progress of welded bridgework have been closely followed from the start by the author who was thus in a position to give careful consideration to all aspects of the question, and who submitted to Mr. J. H. Condy, M.Sc., M.Inst.C.E., M.I.Mech.E., the Civil Engineer to the Board, proposals for both riveted and welded alternatives. As the welded designs were considered to offer advantages both as regards initial cost and subsequent maintenance, their adoption was sanctioned by the Chief Engineer to the Board, Mr. V. A. M. Robertson, M.C., M.Inst.C.E., M.Inst.Mech.E., M.Inst.T., F.S.E.

It must be pointed out that the advantages of welded construction had been clearly demonstrated in the past by means of comparative designs in many branches of engineering, but the adoption of the welded alternatives had been vetoed only too often for the sole reason that

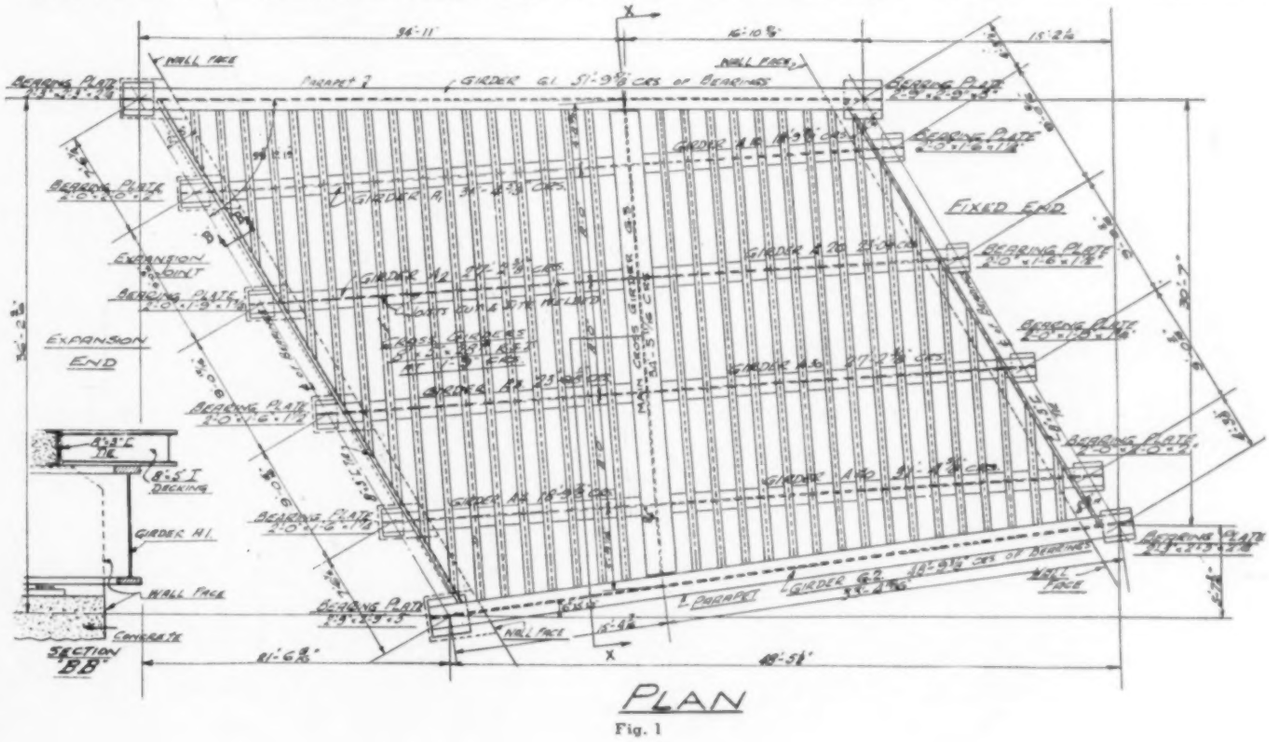



Fig. 1

there were no examples of similar work in the country. In view of this unfortunate tradition the action of the Board's engineers is worthy of the highest praise and should undoubtedly earn them a place in the annals of railway bridge welding in Great Britain.

The Board's first all-welded bridge was erected over Ladbroke Grove, on the Metropolitan Railway system, in August 1938, and many points learned in its construction have been used to advantage in the case of the Hainault bridge. We trust that the lower initial outlay, absence of vibration, lower maintenance costs and excellent appearance of these bridges will make them the forerunners of many others.

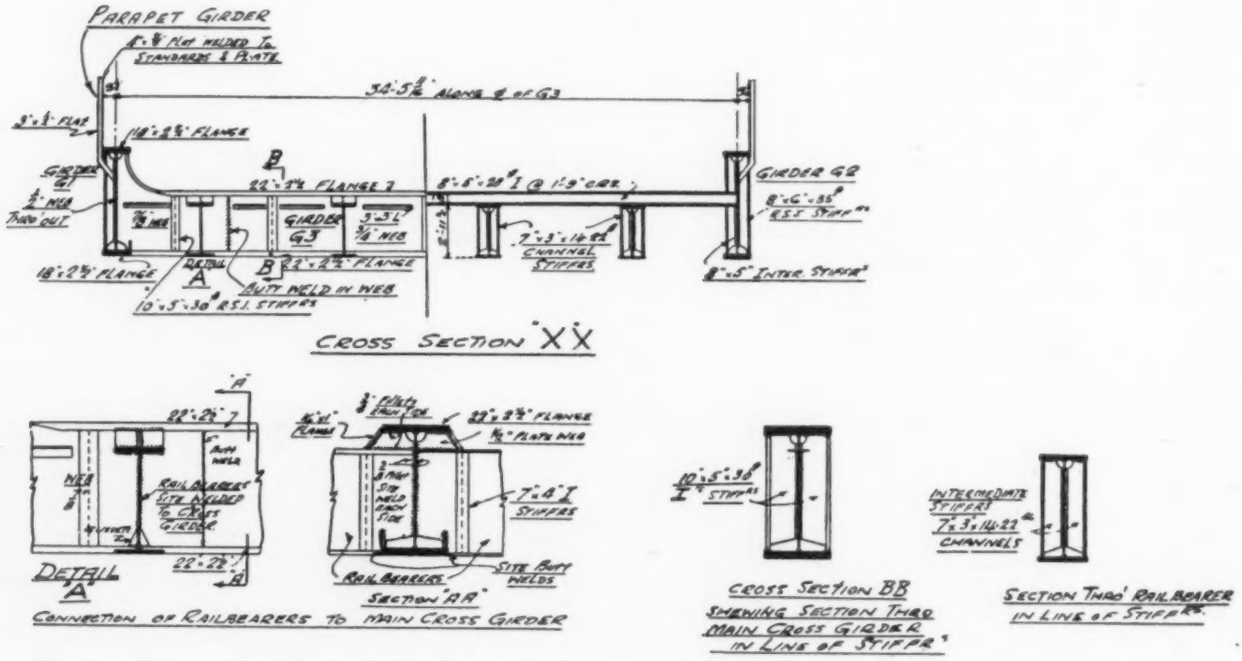
## GENERAL SCHEME

One of the new bridges which have been built in connection with the work now being carried out by London Transport on the extension to Ongar is of all-welded construction.

It carries the line approaching the new depot at Grange Hill over the New North Road at Hainault.

The clear square span is 40 feet between the faces of the abutments, but owing to the layout of the tracks which it carries, the main girders are placed at different angles, forming a plan as shown on Fig. 1. These girders are 54 feet $3^5/_8$ inches and 51 feet $3^3/_8$ inches over-

Fig. 2


PARAPET GIRDER
CROSS SECTION "XX"
GIRDER G3
GIRDER G2
DETAIL A
CONNECTION OF RAILBEARERS TO MAIN CROSS GIRDER
SECTION "AA"
CROSS SECTION BB
SHEWING SECTION THRO MAIN CROSS GIRDER IN LINE OF STIFFR.
SECTION THRO' RAILBEARER IN LINE OF STIFFRS.

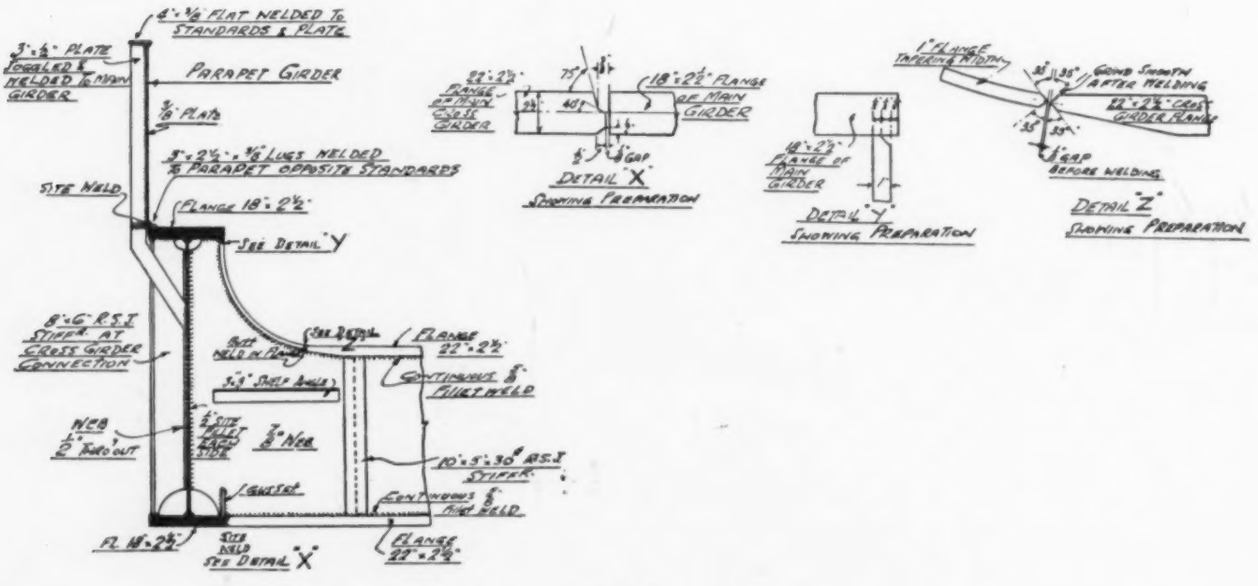



Fig. 3

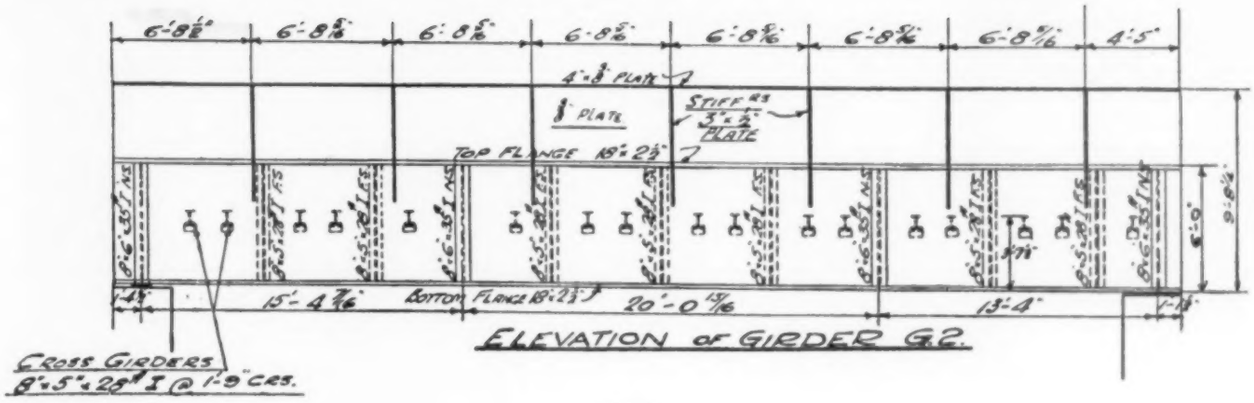



Fig. 4

all, respectively, and between them is one heavy cross-girder so arranged that the reactions are taken up by the main girders well away from the abutments in an endeavor to equalize the deflections of the main girders. The cross-girder, a part elevation of which is shown in Fig. 2, supports four parallel lines of built-up rail bearers 2 feet 11½ inches deep. These are all placed so that the soffits are flush with one another. Above the rail bearers and flush with the top of the cross-girder are floor joists of 8 x 5 inches at 28 lb. rolled steel joists, 1 foot 9 inches center to center, the space between which is filled with concrete.

The floor is suitably waterproofed and protected by a covering of brindle tiles.

Parapet girders of the solid type are fixed to each main girder as shown in Figs. 2 and 3, the height of each parapet being 3 feet 8 inches and so arranged that the requirements of the Ministry of Transport are met.

This bridge is the second all-welded underbridge on the Board's system and, so far as is known, also the second in this country. The first one was built in 1938 over Ladbroke Grove, Kensington, and hitherto has proved quite satisfactory. The bridge here described differs from its predecessor mainly in the design of the floor, inasmuch as more construction depth was available, and experience gained in the construction of the Ladbroke Grove bridge was made use of in this.

The layout of the bridge previously described was such that most of the connections between the various members were skew and it is obvious that such connections can be made much more easily by welding than by riveting.

It is estimated that a saving in weight of approximately 20% in comparison with a similar riveted design was made, and considerable economy in maintenance, reduction in corrosion and increase of life should follow.

The material used, with the exception of the phosphor bronze in the bearings, was mild steel, which was in accordance with the British Standard Specification No. 153, and the welding was done in accordance with British Standard Specification No. 538.

## LOADING AND STRESSES

The bridge was designed to carry a load equivalent to 18 units of British standard loading for railways, and in calculating the stresses due to dead and live load, the worst conditions of loading were applied. An allowance of 50% for impact and vibration was added. The maximum allowable working stress was 8 tons† per square inch in tension, with the corresponding modifications prescribed for compression, and a bearing pressure of 20 tons per square foot was allowed on the concrete bedstones of the abutments.

† Ton = 2240 lb.

## MAIN GIRDERS

Both the main girders consist each of a single web plate 5 feet 7 inches deep x ½ inch thick, with top and bottom flanges 18 x 2½ inches in one thickness as shown in Fig. 4. No curtailments are made in any of the flange plates as the saving of material could be discounted by the cost of butt welds required.

Owing to the disposition of the girders of the bridge, the major portion of the load carried is the concentrated reaction to the cross-girder, and consequently the horizontal shear between the web and flanges is almost uniform, so the ⅜-inch fillet welds on each side of the web were designed to develop the full strength of the web plate along the whole of its length. The girders were designed with end plates in the usual way, but full section rolled steel joists were used as stiffeners. It was decided to omit stiffeners on the outside of the girders except at the point of the cross-girder connection, and a point on the girder symmetrical with this, but on the inside the stiffeners were placed at intervals as shown on Fig. 4. The outer stiffeners were of 8 x 6 inches at 35 lb. rolled steel joists, while the inner ones were of 8 x 5 inches at 28 lb. rolled steel joists, the corresponding views of the main girders during fabrication being shown in Figs. 5 and 6, respectively. In the adoption of this type of stiffener it is claimed that less preparation is necessary and less distortion is likely to arise when the welding is done. The joists were cut at top and bottom as may be seen in Figs. 6 and 7, access spaces thus being provided by radial cuts of 3 inches and 7 inches, respectively. In this way perpendicular faces were left at each end for welding to the flanges, and in addition the amount of welding in a direction at right angles to the line of stress is reduced to a minimum. The connection to the bottom flange contains no corners in which rainwater can lie, which is a decided advantage. The amount of work required in making and fitting this type of stiffener compares favorably with operations required in fitting flats or tees or a split rolled steel joist. In effect it has proved quite efficient and in appearance does not leave much to be desired.

## MAIN CROSS-GIRDER

The section of this girder is very heavy, owing to its restricted depth. Like the main girders, it is composed

of a single web and flange plates, the sections of which are 3 feet $2^1/_2$ inches x $^3/_4$ inch and 22 x $2^1/_2$ inches, respectively. The section of the web plate is increased at each end to $^7/_8$ inch thick, and this in turn is shaped as shown in Fig. 2. The main welding between the flanges and the web is composed of $^3/_8$-inch continuous fillet welds over the central portion of the girder, which are increased to $^5/_8$-inch fillets at each end. The stiffeners are of 10 x 5 inches at 30 lb. rolled steel joists which are cut at the top in the same way as those of the main girders, but have a straight cut at the bottom as shown on cross section *BB*, Fig. 2. The ends of the girder are shaped for landing on and site welding to the main girders in the course of erection. The girder is 34 feet $5^{11}/_{16}$ inches between the centers of the center lines of the main girders at the points to which it was welded.

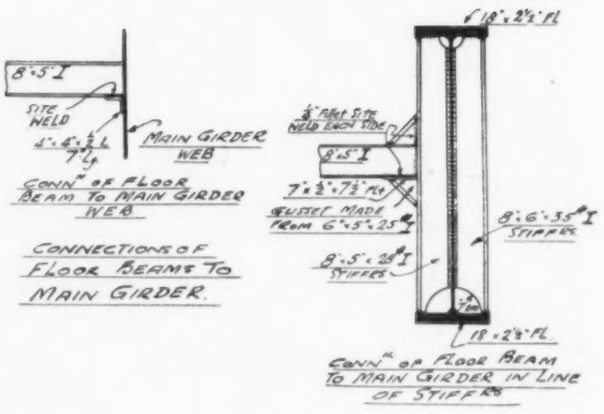



Fig. 7

## CROSS-GIRDER TO MAIN GIRDER CONNECTION

This connection, the details of which are shown in Fig. 3, has to transmit a very heavy concentrated load to each main girder. It has been adopted as a general principle in all the girder connections in this bridge, that wherever possible the depth of the shallower girder should be increased to equal the full depth of the deeper through girder. By this means the reaction is distributed over the whole of the increased depth and the deepened web plate also acts as a stiffener on one side of the through girder. In addition, a flange or cover plate is welded on to the top of the deepened portion, and is intended to resist the tension which may occur if a negative bending moment is induced in the connection due to its rigidity as a welded joint.

Two small triangular gussets are in general welded to the web of the shallower girders to assist in landing and erecting on the bottom flange of the through girder, and materially assist in holding the girder in position while the top cover plate, deepened web and bottom flange of the secondary girder are welded on the site.

In the case of the connection in review no negative bending moment of any magnitude is anticipated as the main girders have not sufficient lateral rigidity to provide a high degree of fixity to the connection apart from its own inherent rigidity. A top cover or flange is, however, adopted to accord with the section of the cross-girder flange as shown in Fig. 8. This plate is 1 inch thick, and is curved and shaped to avoid local concentrations of stress which might occur in corners in such a heavily loaded connection. The section of this cover plate is not therefore justified by calculation, but by reasoning and considerations of proportion.

In this connection it will be noted that the bottom flange of the cross-girder is welded to the flange of the main girder by a single-vee weld with a sealing run under the flange, as shown by detail *X*, Fig. 3. This sealing run, together with similar runs on the connections of the longitudinal rail bearers, are the only overhead welds incorporated in the design.

The web of the main girder on the outer side of this connection is stiffened by means of an 8 x 6 inches at 35 lb. rolled steel joist, and a view of the cross-girder at the completion of the shop work is shown in Fig. 9.

## RAIL BEARERS

These girders vary in section according to their spans from a single web plate 2 ft. $10^1/_4$ inches x $^1/_2$ inch and two 16 x $^5/_8$-inch flange plates, one top and bottom, to a single web 2 feet $8^3/_4$ inches x $^1/_2$ inch, with 16 x $1^3/_8$-inch flanges.

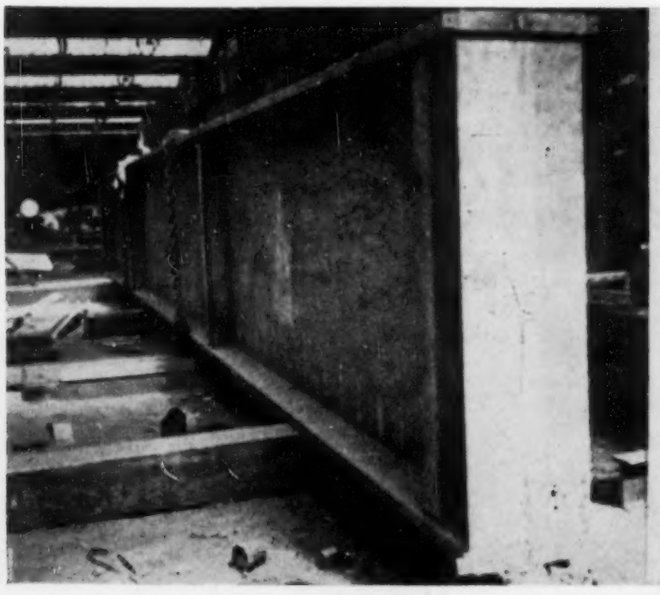


Fig. 5

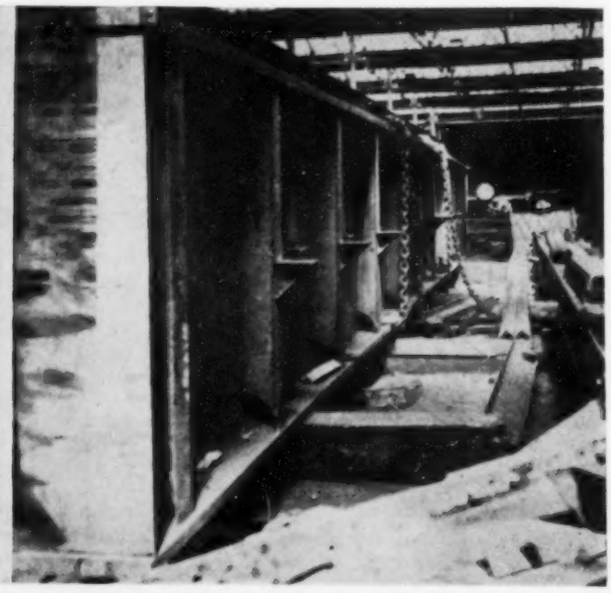
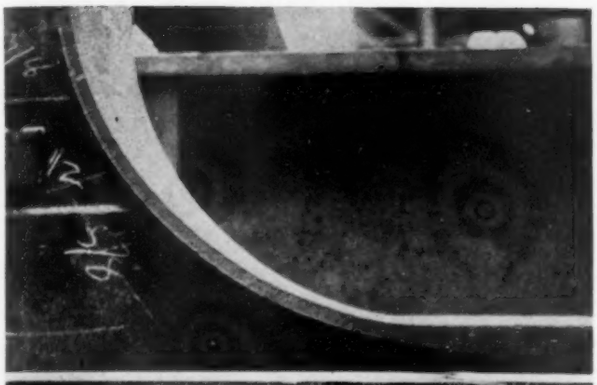


Fig. 6

Fig. 8



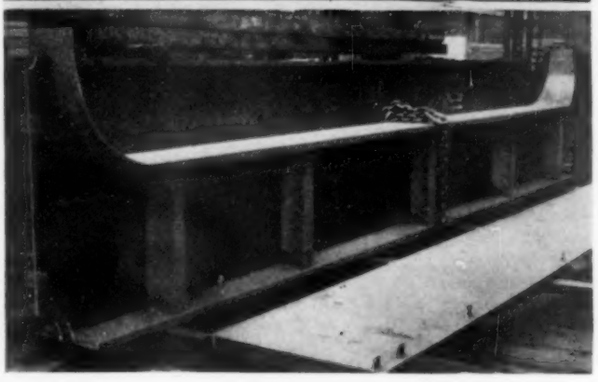


Fig. 9

Each span is designed as a simply supported beam as little advantage is gained from the continuity of the rail bearer over the cross-girder support when only one span is loaded. The advantage of continuity does, however, contribute to the general rigidity of the structure, and it was therefore adopted. The fillet welding of the flanges to the web varies from $^1/_4$-inch leg length at the center portions of the girders to $^3/_8$-inch leg length fillets at the ends. All stiffeners are of 7 x 3 inches at 14.22 lb. rolled steel channels, and at each of the bearings over the abutments two channels are placed back to back on each side of the web. All stiffeners are shaped in a similar way to those of the cross-girder, as may be seen from the right-hand end of Fig. 2.

## RAIL BEARER TO CROSS-GIRDER CONNECTION

This connection makes the two rail bearer spans continuous over the cross-girder, and is of a similar type to that already described for the cross-girder to the main girder. The cover plates in this instance, however, are flat owing to the smaller difference in depth between the rail bearer and cross girder and the smaller load being transmitted. They are designed to resist the full tension due to the negative bending moment which occurs when both spans are fully loaded. Triangular gussets for landing on the cross-girder are also provided and the bottom flanges of the cross-girder and rail bearers are welded as previously described for the cross-girder connection. The full details of this connection are shown in detail *A*, Fig. 2.

## FLOOR BEAMS

The floor is made up of 8 x 5 inches at 25 lb. rolled steel joists at 1 foot 9-inch centers, which rest on the rail bearers at right angles to them. They are supported on the main girders at their extreme ends. Each span between rail bearers is designed as a simply supported beam. The beams are put in position in two lengths, the joint being over alternate rail bearers, and are connected by positioning welds each side of the bottom flange. The erection was facilitated in this way. The ends of floor beams, which rest on the abutments, are welded to a rolled steel channel 8 x 3 inches at 15.9 lb., which lies parallel to the face of the abutments and at a short distance back, as shown on section *BB*, Fig. 1.

## CONNECTIONS OF FLOOR BEAMS TO MAIN GIRDERS

The connections of beams which run on to the stiffeners of the main girders are designed to impart additional lateral rigidity to the structure. Triangular pieces of 6 x 5 inches at 25 lb. rolled steel joists are used to form a tee gusset at the top and bottom of the beam. The floor beam is landed on a plate on the lower gusset, which is shop welded to the stiffener and the welding was completed on site during erection.

The connections of beams running into the webs of the main girders are flexible, both for economy and simplicity. Under each beam is a 4 x 4 x $^1/_2$-inch angle cleat which is shop welded to the web. The top corner of the cleat is chamfered so that the weld does not rise above the level of the outstanding leg of the cleat and this allows the beam to butt closely against the web. The bottom flange of the beam is merely welded to the cleat. The details of both the above types of connection are shown in Fig. 7.

The whole of the space between the floor beams is filled by a 6 to 1 mixture of concrete.

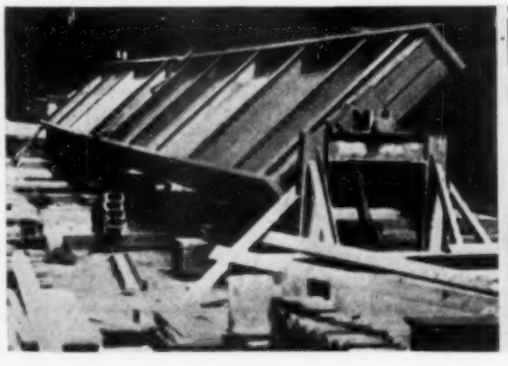


Fig. 10

Fig. 11

Fig. 12

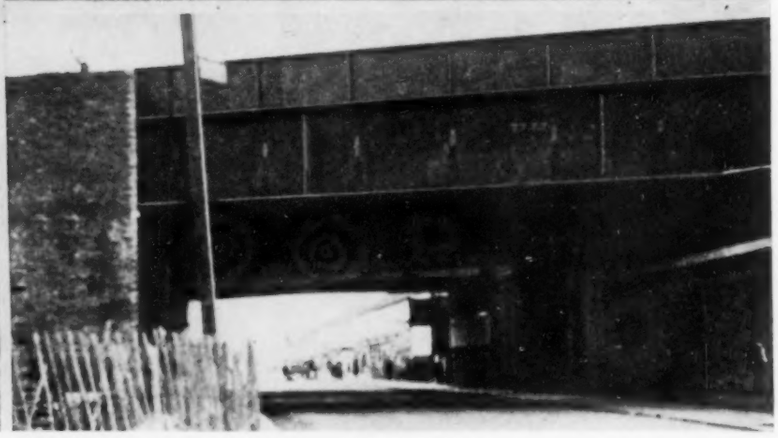


Fig. 13 (Top)
Fig. 14 (Bottom)

## PARAPET GIRDERS

The parapet girders shown in Figs. 2, 3 and 4 consist of a single plate $^3/_8$ inch thick, to the top of which is welded a horizontal cap 4 x $^3/_8$ inch. These plates are connected to the main girder by flats 3 x $^1/_2$ inch on the outside, which are carried below the top flange of the main girder and on the inside by landing lugs, one opposite each flat. This arrangement not only proves an efficient and economical fixing, but has the effect of stiffening the compression flange of the main girder. The parapets were made in two pieces and site-welded after erection.

## BEARINGS AND CAMBER

The bridge was designed so that provision for expansion could be made. One end of each of the main girders and rail bearers was fixed to the abutments and the other left free to slide on phosphor bronze strips.

The whole structure was built to a camber of 3 inches in the over-all length of 70 feet.

## PROCEDURE

Before the work of welding, both in the shops and at site, was put in hand, a careful study of procedure was

Fig. 15

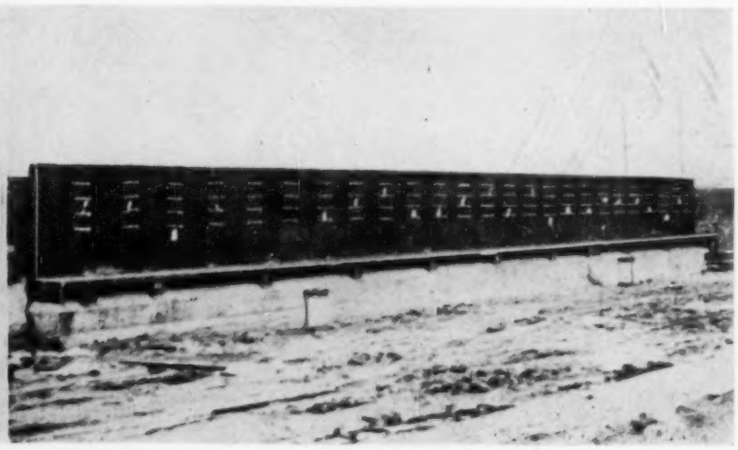


Fig. 16

made and a chart setting out exactly the methods to be followed was issued. The result was that the work was executed without a hitch and the distortion of the steel work was reduced to a minimum. The welding was carried out under the supervision of the Board's Resident Inspector, Mr. J. K. Piry.

During fabrication the girders were supported on temporary trunnions so that the main welding was done in the downhand position, thus enabling the use of larger gages of electrodes. The remainder of the shop welding was done in the horizontal position, and one of the main girders in the course of fabrication is shown in Figs. 10 and 11. The erection of this girder is shown in Fig. 12, while Fig. 13 shows the main members of the bridge in position. The elevation of the bridge, with the brickwork as yet unfinished, is shown in Fig. 14, and a view of the underside of the deck is shown in Fig. 15. Figure 16 shows the deck inside the parapet with the cable brackets welded on but the track not yet laid, and gives a good idea of the width of the bridge.

The main contractors for the steelwork were Messrs. Braithwaite & Company (Engineers) Ltd., Newport, and the subcontractors were Messrs. Askham and Palin for the erection and the C. and M. Welding Company Ltd. for the site welding.

The whole of the structure was built to the design and requirements of the London Passenger Transport Board.

---

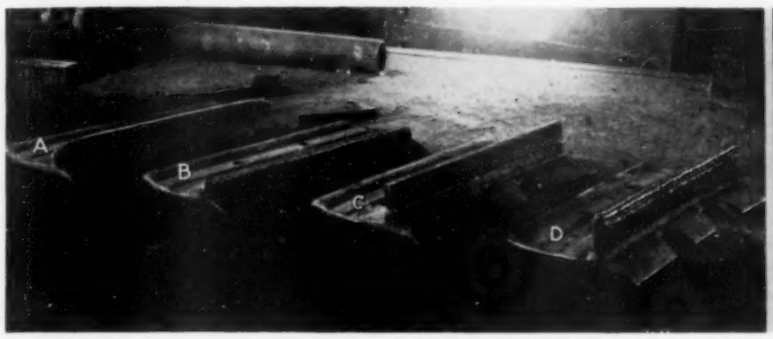



**Fig. 1—Track Pads for Crawler Tractor**

*A.* Worn pad. This pad is in for repair for the second time. The bar with which it was rebuilt is completely worn away
*B.* Pad trimmed to a smooth edge with cutting torch
*C.* Pad with steel bar in place
*D.* Repaired pad bar welded in place and hard surfaced. In dirt or gravel the service life of a rebuilt pad is equal to that of a new pad. It is not recommended that rebuilt pads be placed on a machine that is in use on rocks. The steel bar is welded to the pad with coated mild steel rod. The hard surfaced material on the bars is a special alloy cast-iron rod developed at Fort Peck and patented by the U. S. Army Engineers. By rebuilding the worn pads rather than purchasing them new, an average saving of approximately 70% has been realized on each pad

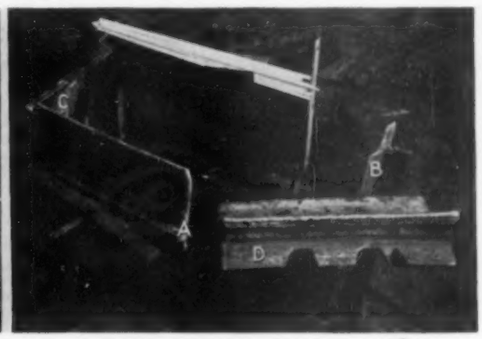



**Fig. 2—Revolving Jig for Track Pad Repair**

*A.* Pad in place for first weld. Bar used for build up, lays in front of pad
*B.* Position for welding and hard surfacing ends of bar
*C.* Position for final weld and hard surfacing front of bar
*D.* Position for hard surfacing top of bar
Shield in center of jig is welded to the shaft on which jig is mounted. This shield protects helper from arc burn. The helpers position is directly opposite from the welder. The helper places the pads and bars on the jig and position pads for welding, he also trims pads with cutting torch. The use of this jig cut the cost of pad repair 50%

# Repair of Mechanical Equipment by Welding

By W. M. GALLOWAY*

IN PREPARING this article the writer has taken a few of the pieces of equipment that have been repaired in the U. S. Engineering Department Dragline Shop at Fort Peck as examples of the saving that can result from the use of welding. The accompanying photographs indicate the work accomplished and a brief description of the work involved is given in the following paragraphs.

The service life of a repaired sprocket is equal to that of a new sprocket and a saving of 60% of the cost of a new sprocket wheel is effected by the repair (Fig. 3).

This sprocket can best be repaired on the tractor. The tracks must be removed and tractor blocked up to allow sprocket to be turned. The metal plates placed on sprocket to replace worn portion were cut from a piece of steel pipe. The size of the pieces required can best be found by cutting a template from a piece of light gage metal, and fitting the template to the worn part of the sprocket, then placing it on the pipe for a cutout mark. The plates are welded in place with a mild steel coated rod (Fig. 4).

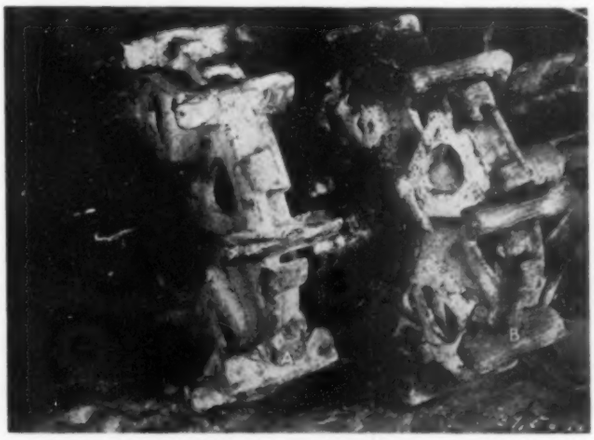



**Fig. 3—Drive Sprocket for Crawler Type Power Shovel**

*A.* Worn sprocket. This sprocket was new when placed on machine. Present condition is after one year service
*B.* Rebuilt sprocket. Sprocket *B* was in about the same condition as Sprocket *A*. For repair the sprocket is mounted in a jig so that it can be turned to allow all welding to be done in a down-hand position. The worn parts of the sprocket are built up to the same size as a new sprocket. The rod with which the sprocket was repaired is a high-carbon rod

* U.S.E.D., Fort Peck, Montana.
This discussion represents only the personal opinions of the author and in no way reflects the official attitude of the U. S. Army.

The cost of rebuilding a sprocket by this method, including the pipe from which plates were cut, rod, labor, etc., is 80% less than the original cost of a new sprocket installed on the machine. Although the service life of the rebuilt sprocket is $^2/_3$ of that of a new one, a substantial saving is realized. When the plates wear down to where it is necessary to replace them the remaining weld metal and plate can be removed with a cutting torch and new plates welded in place. The writer has repaired sprockets four or five times and they are still in service.

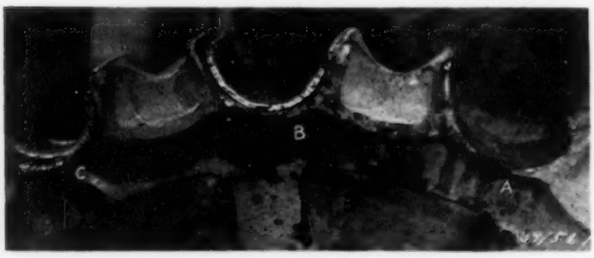



**Fig. 4—Drive Sprocket for Crawler Type Tractor**

*A.* The section of sprocket over *A* is before repair
*B.* Metal plate in place before welding
*C.* Repair completed plate welded in place

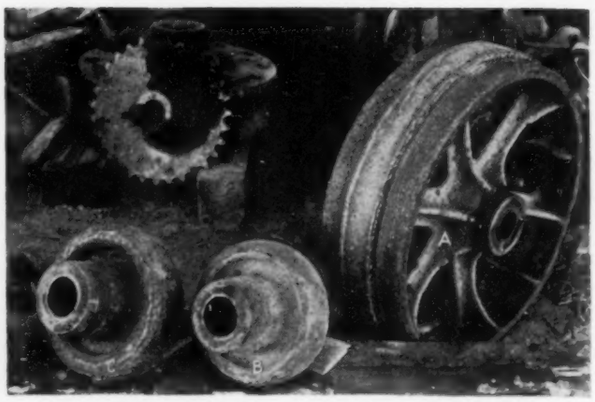



**Fig. 5—Tractor Track Idler and Dragline Rollers**

*A.* A front idler for a crawler tractor. The worn idler should be mounted on a jig so that it can be turned for ease of welding. The rod with which the idler is built up is a high-carbon steel rod. Savings as high as 50% of the cost of a new idler are obtained by rebuilding and the service life of the rebuilt idlers have proved to be longer, in some cases, than that of the new ones

*B.* Track roller for dragline after one year service

*C.* Roller of same type as *B*, after rebuilding to same size as new roller. Rollers of this kind are repaired by bending two flat steel bars around the roller, welding them fast as they are bent. A space is left between the bars for weld structure, also a space is left on the outside edges. The spaces are built up to the same height as the bars and the wearing surface of the roller covered with a wear resisting metal which contains the following named elements: chromium, silicon, manganese, iron and carbon. The bars are welded to the roller with coated mild steel rod

The service life of a rebuilt roller is equal to that of a new roller and the cost of rebuilding the roller is approximately 60% of the cost of a new roller

# WELDING in the AIRCRAFT INDUSTRY*

By L. P. WOOD†

I AM dividing the subject of this talk, "Welding in the Aircraft Industry," into two general classes; one is torch or gas welding as used in the aircraft industry and the other is resistance welding. Both classes will be broken down into the several types which are most commonly used on aircraft. My remarks on gas welding will be limited and only of a very general nature since my experience with welding has been primarily concerned with resistance welding. I will not discuss arc welding, which is the third type of welding used in aircraft, because my experience in the design and manufacture of airplanes has been with military airplanes and, for the past several months, with commercial airplanes also, on neither of which arc welding was used.

Gas welding on aircraft is applied to carbon steels, notably of the chrome-molybdenum type, corrosion-resistant steels, nickel-chromium-iron alloy, aluminum alloys and, to a small extent, magnesium alloys.

Practically 100% of the welded steel structural parts in commercial and military aricraft are made of chrome-molybdenum steel, S. A. E.—4130. This particular alloy steel is used because it is a "happy medium" between a steel which is easily weldable, can be heat treated to the high ultimates required in the structural design of airplanes and has excellent air-hardening properties. Even with such an alloy all aircraft manufacturers have probably run into welding, fabrication or heat-treating difficulties, with welded assemblies of 4130 steel.

These difficulties can usually be laid to one of several faults: (1) Poor welding technique. The majority of welders certified to work on Army and Navy jobs are usually fairly young. This is because the industry itself is relatively young and it is a fairly well-established fact that men who have years of welding experience in other trades are unsuitable to do work of the high quality demanded on aircraft.

Before working on military aircraft for the government agencies, welders are required to pass a qualification test which is quite rigid and requires unusually high-quality work. The test consists of welding four types of joints: open single vee butt weld in $^1/_4$-in. plates, open tubular butt weld in tubing from 0.028-in. to 0.065-in. wall thickness, vertical fillet weld made of three $^1/_4$-in. plates and a cluster weld consisting of three tubes of 0.065-in. wall thickness welded to $^1/_4$-in. plate. The first three joints are strength tested and must meet certain minimum requirements and the three-tube joint is sectioned, etched and examined microscopically to determine weld penetration and for presence of blowholes or porosity. Welders are classed according to

* Paper presented at the May 14, 1940, meeting of the New York Section of the AMERICAN WELDING SOCIETY.
† Head, Materials Department, Aviation Manufacturing Corporation, Stinson Aircraft Division, Wayne, Michigan.

method of welding, alloys they may weld and whether they may work on structural or non-structural parts. The tests described are for carbon and alloy steels. Tests required for aluminum and aluminum alloys, stainless steel and other metals are less extensive and consist mostly of visual examination and bend tests. The reason for this is that such metals are generally not used in highly stressed parts when welded.

Aircraft welding is usually done on fairly light gage material and this is another reason why men with other welding experience have difficulty changing over to aircraft welding. The majority of new aircraft welders come from vocational schools, factory training schools, or commercial schools whose courses in welding are designed with the primary purpose of training welders for aircraft. Army and Navy qualification tests and Magnaflux and other types of inspection of production work are responsible for maintaining high quality in aircraft welding.

Another fault was found in the design of highly stressed parts—such as landing-gear struts, tail-wheel supports, fittings and similar parts which must be heat treated after welding to tensile strengths ranging from 150,000 to 190,000 psi. Where such parts consist of a light plate or thin-walled tubing welded to a forging which usually has much heavier sections, it is difficult to bring the forging to the required tensile strength and still keep the tubing within acceptable hardness limits. Failures or difficulties due to materials are very infrequent because of rigid specifications and the consequent high quality of tubing and forgings now obtainable. However, due to the great amount of experience the industry has in the design and manufacture of welded assemblies, difficulties have been considerably reduced.

Welded steel construction in military aircraft reached its peak about eight years ago. Since then it has steadily decreased due to the development of monocoque designs and the use of stressed skin of high-strength aluminum alloy and cantilever wings. This type of construction favors the use of high-strength, light-weight aluminum alloys, rather than welded-up structures of heat-treated alloy steels. Gas welding of alloy steels in military aircraft will probably not decrease much from its present level because it is still a highly desirable method of manufacture of engine mounts, landing gears and miscellaneous fittings. Gas welding of stainless steel and, in recent years, the chrome-nickel-iron alloys, such as Inconel, are used extensively in the manufacture of exhaust stacks and collector wings because of their excellent stability at elevated temperatures.

The use of welded tube construction now finds its greatest application in the private airplane field and probably will predominate here for some years to come. In light, low-speed airplanes not intended for high performance, welded tube construction at present offers the most satisfactory method of construction because commercial airplane mechanics are more familiar with this type of construction, and high rate of production is possible with a minimum of special tools and jigs. However, several commercial manufacturers have already put all-metal private airplanes on the market and it is only natural that the others will follow as methods are developed which will make this type of construction less expensive.

These remarks on gas welding have only been of a general nature because numerous papers have been presented and articles written by persons more familiar with details of the process than I am.

Resistance welding has been of primary interest to me because it offered me my chance to get in the aircraft industry and because the development of procedure and design control occupied the greater part of my time for the first couple of years. It is this type of welding with which I am quite familiar.

There are three types of resistance welding used on aircraft; namely, flash-butt welding, seam welding and spot welding. Because of the limited use of the two former, I will only mention them briefly. Flash-butt welding is used in welding tubes to forgings in the manufacture of control rods and similar assemblies. Flash-butt welding on aircraft is limited because it is essentially a high production tool and there is a relatively small production of any single airplane design. An airplane manufacturer is extremely fortunate if he can tool for 500 airplanes of a single type while it is commonplace for automobile manufacturers to tool for 500,000 units.

Seam welding—which is nothing more than a series of overlapping spot welds made, of course, on machines especially designed for seam welding—is used to some extent in the manufacture of fuel and oil tanks of aluminum alloy and exhaust stacks of stainless steel.

Of all the types of welding I have mentioned, spot welding is my favorite because I "grew up" with it at Curtiss Aeroplane and followed it from all angles: design, quality control of process, testing and supervision of equipment installation and maintenance. From a beginning of one welder for aluminum alloys and several small ones for stainless steel, they now have about double the number of stainless steel spot welders in addition to a seam welder for stainless steel and four machines spot welding aluminum alloys exclusively. All this has taken place in the short period of four years. Similar progress in the application of spot welding to aircraft has been taking place throughout the industry.

At the outset manufacturers held back in spreading the use of spot welding too rapidly for several reasons. Compared with other methods of fabrication, spot welding is quite new. The first actual welder was built and operated in 1901, and it was some years later before it was used as a manufacturing tool. Aircraft manufacturers also were cautious in the use of spot welding because the alloys they weld, mainly stainless steel, aluminum alloys and magnesium alloys, are much more critical to weld than alloys commonly used in other industries. The welds also lacked the uniformity and high quality demanded in aircraft workmanship. It has probably been just as well that the aircraft industry did start out slowly and gradually expand the use of spot welding as their knowledge, experience and service tests of the process increased. This has prevented the use of spot welding on aircraft from getting a bad name due to reports of failures in service. Due to the fact that spot welding was first applied only to non-structural assemblies and then gradually spread to semi-structural and then to structural assemblies, there have been very few unfavorable reports on spot welding.

At the present time, spot welding has ceased to be a novelty in aircraft factories and is a standard production tool universally used and accepted. Of course, the use of spot welding on structural parts has only begun to get a foothold. Just how far this method of fabrication will be used along these lines remains to be seen. It is known, however, that spot welding of structural parts is more universally used in Europe than it is here. It is interesting to guess the possible reasons for this. One of them is quite obvious and that is the fact that both services in this country, the Army and the Navy, demand that new methods, or processes, be conclusively proved in laboratory and in service tests before they will permit free use of them. Such a system insures them of getting a high quality airplane which they can be sure is absolutely dependable. Of course, European coun-

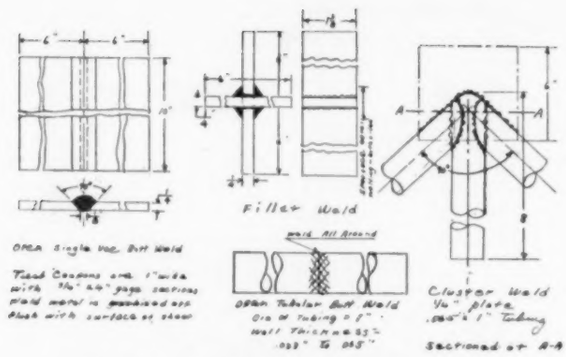



Fig. 1—Qualification Test for Aircraft Welders

tries may feel that the process has already been proved to their satisfaction and hence they are ready to approve the widespread use of spot welding that is done. This brings up the point of whether they are more advanced than we are in the art of spot welding and manufacture of spot welding equipment.

It is my opinion that they definitely are ahead of us. One fact that proves this is that they use spot welding so universally and use it quite successfully. Another reason is that I have operated European equipment and made numerous tests on welds made on this equipment and, from the results of these tests, I can say that their equipment produces a superior weld. I am referring to the Sciaky welder, a French product. This opinion is substantiated by the fact that during the past year when all manufacturers have been expanding their plants and buying quantities of new equipment to handle the tremendous orders being received, both domestic and foreign, by far the greatest percentage of spot welders bought by American manufacturers have been Sciaky welders. I will give more details on the Sciaky equipment and process later.

The theory of resistance welding is a basic principle of electricity, namely, that heat is produced in an electrical circuit in proportion to the resistance of any part of the circuit. Advantage is taken of this by passing a controlled current of high amperage at low voltage through two or more pieces of metal at the point of contact while the metals are under pressure. The surfaces of metal in contact are made the point of highest resistance and, consequently, heat is produced to make the metals plastic or, as in the case of aluminum alloys, molten, and a forging action takes place.

The aircraft industry demands spot-welding equipment which will have the following features:

1. Flexibility.—Because of lack of high production as compared with the automotive and other industries, and because of the variation in type of parts assembled by spot welding, machines designed for use on aircraft parts must be flexible. An aircraft manufacturer cannot afford to buy a machine to do just one job as is done in the automotive industry. All of his spot welders must be flexible enough so that each can handle a high percentage of the parts that are welded. This, of course, does not apply to actual output of the machine. Such a machine must have a fairly long throat depth, numerous types of electrodes and a wide possible variation in pressure, current and timing.

2. Transformer Capacity.—Aluminum alloys require from five to ten times the amount of current that ferrous alloys require.

3. Accurate and Controlled Timing.—Aluminum alloys have a very short temperature range between the solid and molten states, hence, since heat is also a function of time, it is necessary that the length of time current flows be accurately and positively controlled. If this is not done, the welds will either be weak or a hole will be blown in the metal.

4. Positive Pressure Control.—Pressure is another critical item because of the reasons just given for the necessity of accurate timing.

5. The upper or movable arm of the welder must be as light as practicable and its travel must be reduced to a minimum to prevent "hammer below" on the relatively soft aluminum or magnesium alloys as pressure is applied to the work.

6. Electrodes must be of a design and a material which can be easily kept clean and readily replaced. This is necessary because aluminum has a definite affinity for copper alloys and the tips, which contaminate quickly, must be kept clean and of uniform shape so that resultant welds will be clean and uniform.

Of course the characteristics enumerated are desirable in any spot welder, but the degree of refinement varies with the type of work done and a very high standard has been set in the aircraft industry. The reason for this is obvious. Where the failure of a spot-welded assembly in an automobile may only mean a repair is required, a failure of a spot-welded joint in a stressed part of an airplane may result in the loss of "plane and pilot."

The problems to be overcome in the application of spot welding to aircraft construction arise naturally from the degree of safety that is demanded of structures which are constantly submitted to various stresses, as shear, tensile and repeated loads, bending and vibrations. As a rule, aircraft structures are generally designed fairly close to the limit in order to obtain the best balance between strength and weight and still make the airplane safe. This is more true on military ships than commercial ships because in the former, performance is a highly essential quality. For this reason spot welds should not constitute a weak spot in a finely calculated structure and, also, it is essential that their properties should be well established so that exact allowance may be made for them in calculating the design of the structure.

The reason for the need of flexibility in the spot-welding equipment has been explained. High transformer capacity with fairly small control steps is necessary because aluminum alloys have a low electrical resistance compared to ferrous alloys, and alternating currents ranging from 15,000 amperes to 35,000 amperes are necessary to cover the range of alloys and gages usually welded in an airplane factory. Machines which use

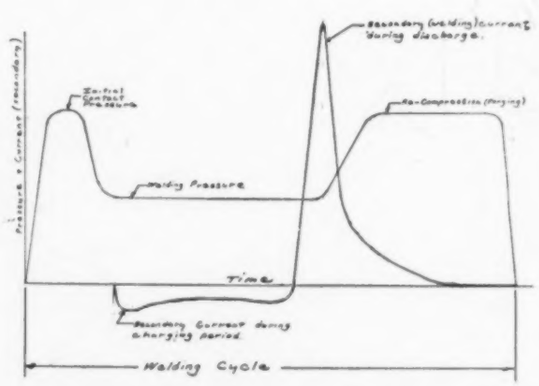



Fig. 2—Sciaky Variable Pressure and Stored Energy Cycle

direct current develop considerably higher amperage but for shorter periods of time. Accurate and controlled timing is essential for several reasons. If metals are welded in a short enough time, it is theoretically possible to generate the necessary heat at the location of the weld, fuse the surfaces together, and allow the heat to be conducted away by the surrounding metal and electrodes without heating the outer surface or surrounding areas of the metal to an injurious temperature. The smallest errors in timing may cause variations in the quality of the weld by causing the metal adjacent to the weld to lose the various properties imparted to it by heat treatment, by oxidizing the surfaces of the sheets and thus promoting corrosion, and by causing the sheets to warp. Due to the plasticity of such metals as aluminum and magnesium alloys, positive and accurate pressure control is necessary to produce uniform welds and to prevent rapid deterioration of the electrode tips. It is necessary that the upper, or moving head, be as light as possible to reduce the inertia loads and to minimize mechanical damage or distortion to the relatively soft alloys, as aluminum and magnesium. This is especially true in light gage parts which form the greatest part of aircraft structures.

There is one other highly important factor relating to aircraft spot-welding equipment. The electrodes and electrode tips used in the spot welding of aluminum and magnesium alloys must have several characteristics. They must be of rugged design to withstand without deflection the high electrode pressures used. They must be made of a material which has a high electrical and heat conductivity to prevent heating between the electrode and work contact and to conduct the welding heat away as rapidly as possible. They must also be fairly hard so that they will have a fairly long life and will not deform under pressure at elevated temperatures. There are several alloys of this type on the market having electrical conductivities of approximately 85%, correspondingly good heat conductivity and physical properties equal to mild steel.

Electrodes for welding of stainless steel are somewhat different. They are usually forged or machined from rolled or hard-drawn copper and then the welding tip is made by inserting material which is considerably harder than the alloys used on aluminum, but has only about one-half to two-thirds the conductivity.

Design control, jigging and welding technique, preparation of material and procedure control of aircraft spot welding are fairly consistent throughout the industry.

To control design of spot-welded assemblies, standards are established and issued to the engineering department which outline the various possibilities and limitations that must be considered. Such information will give

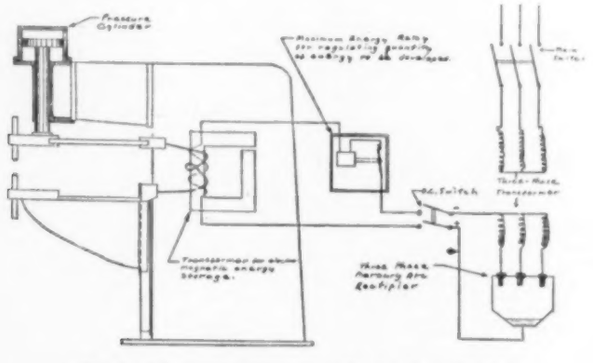


Fig. 3—Schematic Diagram of Sciaky Spot Welder

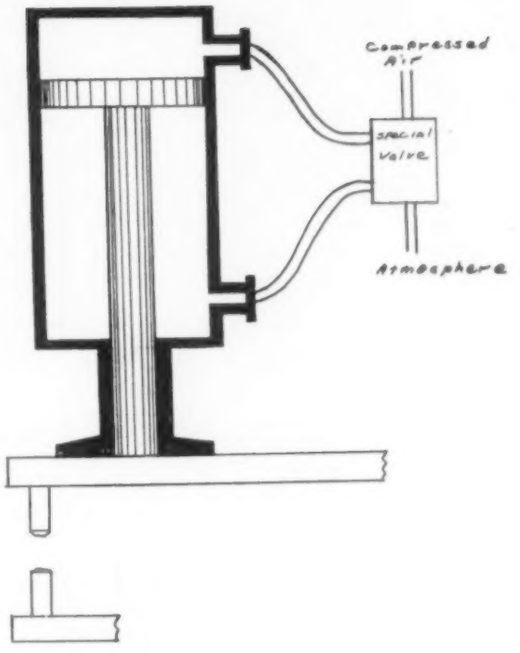



Fig. 4—Schematic Diagram of Sciaky Method of Obtaining Variable Pressure

standard flange and channel dimensions, width of lap joints, spacing between welds and the allowances which must be made in design in order that the part will be accessible for spot welding. These standards are quite similar for aluminum and magnesium alloys, but are considerably more flexible and less rigid for stainless steel.

Three methods of jigging are commonly used. Probably the most widely used practice is to drill pilot holes at key points in assemblies, or about every 18 in. along seams, and insert self-tapping screws to hold the parts together. After welding, these holes are filled with rivets.

On certain parts where rivets would be objectionable, clamps are used to hold parts together until tack welds can be made. Where the amount of production warrants the expense, fixtures are made to hold parts for welding. This latter method is used extensively in the manufacture of stainless steel spot-welded assemblies. The part will be assembled on a form which in some cases may consist of a copper block, or wood block, lined with strips of copper; tack welding is done and then they are removed from the form and finish welded.

Welding technique, or proficiency in welding, is only acquired by practice. In order to insure that the work turned out by the spot-welding department would be of high quality, I have successfully used the following plan in training operators: Select a man who is a fairly highly skilled mechanic, one who can work fast with his hands. Operators need have no knowledge of how the welding they are doing is accomplished because present-day equipment is almost completely automatic. However, the knowledge of the fundamentals of the process will not do any harm and this knowledge is essential in the lead man, or foreman, in charge of welding. The various parts of the equipment which he will have to operate are pointed out to him and their functions explained. He is started to making sample welds on scrap stock. How to recognize poor welds is taught him by deliberately making a number of them and pointing out the various characteristics by which he can tell a sound weld. Ease in determining poor and good welds

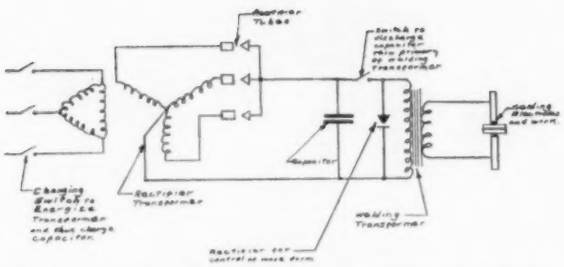


Fig. 5—Schematic Diagram of Taylor-Winfield Hi-Wave Stored Energy Welding Machine

comes with experience. He is then started in production on simple pieces with straight welding and as he acquires proficiency is given more complex assemblies. Spacing of welds is done manually and uniformity in this depends entirely on the skill of the welder. Speed, too, is determined by the welder's ability and by practice.

There are several methods commonly used for preparing materials for spot welding and all are effective. As I have said before, uniformity of welds must be obtained to warrant their use on aircraft. This is one reason why practically all manufacturers resort to either chemical or mechanical means to completely remove the oxide film from the surfaces, so that they will all be uniformly clean and faying surfaces in contact will have equal resistance. Clean outer surfaces also prolong tip life. One method used on aluminum is to make a heavy, gelatin-like solution containing hydrofluoric acid and a wetting agent, brush this along the seams to be welded, allow to stand a few minutes and wash off thoroughly. This leaves an etched surface which is chemically clean. Another method is to completely immerse the parts to be welded in an etching solution, such as hot sodium hydroxide or a similar material which will attack aluminum alloys.

Surfaces are also cleaned by rubbing with emery cloth and steel wool. However, the most widely used method among aircraft manufacturers is to use power-driven wire brushes. Some of the high-strength aluminum alloys have an outer coating of pure aluminum which is quite soft and must be cleaned with brushes having fine stainless steel bristles so that this thin coating will not be removed. Other aluminum alloys and magnesium alloys are cleaned with ordinary crimp steel brushes.

Procedure control is highly essential for the reason that no satisfactory method has yet been developed for production testing of spot welding. The only satisfactory method available at present is to test the welds to destruction. For this reason manufacturers must establish welding standards which they know will give good welds because of numerous tests they must make. Specimens are made at frequent intervals to duplicate the production work going through at any particular time and are tested for strength. Changes from established standards are only made on the authority of the person in charge. Procedure control also governs the external appearance of the weld, uniformity of spacing and general workmanship.

This paper will not attempt to present any information on the strength of spot-welded joints, as this is a subject in itself and requires charts and curves which it would be difficult for me to present to you in an interesting and constructive manner. However, I will call your attention to the fact that manufacturers are gaining more confidence in the strength of spot-welded structure as evidenced by the fact that they are extending this process from semi-structural to structural assemblies.

Cost of spot welds is another item I will only mention briefly. Several reliable sources have estimated the cost of the average spot weld to be between one-quarter and three-tenths of a cent. This compares with the average rivet which various manufacturers estimate anywhere between $1^1/_2$ and $3^1/_2$ cents.

I have intentionally waited until the end of this paper to discuss a very recent trend in spot welding in this country because to me it is extremely interesting and significant.

The first spot-welding machines used by the aircraft industry displayed very little difference from those used in other industries, and this situation has changed little in the past ten years in this country, except, perhaps, that machines used by the aircraft industry are now somewhat more refined and more carefully controlled than those used in other industries. Foreign manufacturers attacked the problem of welding aircraft metals from a different angle. They devoted special study to develop a new type of welding machine. The most successful of such machines is that manufactured by Sciaky, a French concern. When they put their machines on the market, they were very insistent that resistance welding would only be economical provided new methods of manufacture were conceived which were adapted to the new process. This is an excellent system, because it is obvious that if designers confine themselves to merely indicating, on drawings, the use of spot welds instead of rivets, then, as welding is not as practical as riveting in certain cases, production costs of these parts will be high and this will lead to the conclusion that the process does not offer any advantage on this score.

The Sciaky machine embodies two principles which are entirely new to resistance-welding machines as far as this country is concerned. One is the use of direct current for welding by applying the principle of energy storage. The other is their patented variable pressure cycle.

The use of the principle of energy storage permit developing the very high currents necessary, 5000 to 50,000 amperes, without putting excessive peak loads on the main power supply. Sciaky accomplishes this with equipment consisting of a welder with controls mounted on its side and a mercury arc rectifier. The rectifier can be connected to ordinary three-phase shop lines as the maximum demand on the lines is only 350 amperes for aluminum alloy 0.080 in. in thickness.

The fundamental parts of the electrical set-up are a rectifier to convert the three-phase alternating current into direct current which is supplied to the primary of the magnetic "choke," which is simply a transformer for electromagnetic energy storage. A contactor and a maximum energy relay are interposed between the rectifier and transformer. The relay, which is adjustable for the required amperes, serves the purpose of causing the contactor to open when the "choke" has received the pre-selected amount. The machine is then ready to weld in so far as the electrical system is concerned. The variable pressure cycle is accomplished in four steps and consists of applying electrode pressure on the work which is about twice that normally used for welding. This pressure is only applied instantaneously and is then reduced to normal welding pressure during which the weld is made and the pressure again raised to its initial value, held momentarily and dropped to zero.

Pressures can be pre-set individually and the machine can be operated with or without the variable pressure cycle. This rapid changing of pressure is accomplished by means of a pressure cylinder having an upper and lower chamber, the cross-sectional area of the lower

being about half that of the upper and a special value.

In order that the process will be more clear, I will enumerate the various steps in sequence:

1. Pressure and current settings are made in accordance with the material being welded, the work is inserted and the foot button depressed.
2. The pressure value is actuated, opening the lower chamber of the cylinder to atmosphere and connecting the top chamber to the compressed air supply, thus applying initial contact pressure to the work.
3. The lower chamber is then connected to the same air supply decreasing the pressure proportionate to the cross-section areas of the two chambers.
4. The contactor closes charging the "choke" and opens at the pre-set time, causing the stored energy to be discharged, the surge being magnified many times in the secondary, and a weld effected.
5. After reaching maximum, the current tails off in accordance with the exponential law; during this time the lower chamber ceases to be connected to the air supply and is again opened to atmosphere. Since the upper chamber is still connected to the air supply a pressure equal to the initial contact pressure is again applied to the work. This pressure is applied when the welding current has dropped about halfway back to zero from maximum and is held for a certain period.
6. The lower chamber is then connected to the air supply and the upper chamber opened to atmosphere causing the electrode to open to rest position.

The purposes and advantages of the variable pressure cycle and stored energy principle are as follows:

1. The initial contact pressure serves to bring the areas to be welded into good contact and smooth out any roughness in the sheets and permit practically 100% contact over the area covered by the electrode. The final pressure is applied while the welded metal is still hot and a forging process occurs which serves to refine the grain structure of the weld.

The use of stored energy, as I have already said, permits the use of high currents with a minimum of peak load imposed on the power supply. These high currents permit the use of extremely short welding time, one-half a hundredth to three-hundredths of a second. Variations in welding time are accomplished by inserting resistance blocks of various values in the secondary of the transformer. These short welding times, coupled with efficient electrode cooling, keep the contact surface between electrode and work exceptionally cool and thus prevent rapid fouling of the electrodes, or contamination of the work. They also produce a minimum of effect on the metal immediately adjacent to the welded metal. This causes the metal to retain most of the mechanical properties imparted to it by heat treatment and rolling.

Welding done by the Sciaky process has another highly desirable advantage in that it is possible to produce sound, consistent welds in certain aluminum alloys without having to carefully clean and prepare the surfaces to be welded. Also, many more welds can be made before it is necessary to clean or replace the welding tips than is possible with the alternating-current process.

Probably one of the most noticeable differences between welds made by the Sciaky and those made by the A.C. process is the very small deformation obtained in the surface of the sheets with the Sciaky process as compared to a depression ranging from $^1/_5$ to $^1/_3$ of the sheet thickness caused by the electrodes when using the A.C. process.

My opinion that the Sciaky welder is definitely superior to other types of machines is backed up by many others in the aircraft industry and substantiated by the fact that a large number of the major aircraft companies have, in the past twelve months, installed anywhere from one to four Sciaky welders. The advantages of welding by the energy storage method are further confirmed by the fact that one American manufacturer has taken the lead in the field in this country and recently put a machine of this type on the market. This machine uses the energy storage principle but accomplishes it in a different manner than the Sciaky process.

## CONCLUSION

The foregoing statements constitute a general picture of the present status of spot welding in the aircraft industry. Naturally, all subjects mentioned can be elaborated upon and discussed more in detail, but the scope of this paper was such that I could not do this completely. However, if there are any questions concerning particular items, I will be glad to answer them and discuss them more in detail.

---

## MOBILIZING ENGINEERING TALENT

Mobilization of the engineering and architectural professions for national defense is under way now with the preparation by their professional organizations of a nation-wide census of 115,000 engineers and architects skilled in the design and supervision of all types of construction needed in case of national emergency, according to a joint statement made yesterday (June 10th) by John P. Hogan, President of the American Society of Civil Engineers, and Stephen F. Voorhees, representing the American Institute of Architects.

The listing of 15,000 architects at the home of the American Institute of Architects, The Octagon, Washington, D. C., and of 100,000 engineers at the Headquarters of the American Society of Civil Engineers, 33 West 39th Street, New York City, will be carried out in three steps. Each man or office will be classified as to skill in the design and supervision of construction of airports with the necessary drainage, runways, hangars, administration buildings and housing facilities; in water supply and purification plants; in sewage and industrial-waste disposal systems, roads and tunnels; in the enlargement of industrial plants with the necessary housing facilities for workmen, water and disposal systems; in port developments with loading wharves, docks, warehouses and railroads; and in cantonments with barracks, including water, sewage, heating, lighting and other systems, and with the necessary mechanical, refrigerating, heating and ventilating accessories.

The first step of the census, just started, is the listing of engineering and architectural firms, partnerships and individuals in private practice. This is being accomplished by the cooperating national engineering and architectural organizations through special committees in each of their local sections and chapters, which are located in almost every city of the nation and, thus, in a position to provide nearly one hundred per cent coverage. The second step will consist in indexing and classifying each firm or individual according to qualifications so as to permit of ready selection of those best fitted to undertake in any part of the country whatever type of construction would be necessary in the interests of national defense. The final step will be similar to the first two in all details except that, instead of firms, there will be listed and classified architects, engineers, draftsmen, surveyors and specialists, who may be available to work with firms assigned jobs to design and supervise.

In the preparation of the census will be observed the fundamental principle of avoiding the dislocation of those engineers or architects now engaged in industry, in the utilities and in governmental services.

# OXYACETYLENE GOUGING— a Flame-Machining Process*

By R. F. FLOOD†

OXYACETYLENE gouging is a rapid and economical method of removing a U-shaped groove of surface metal from rolled, drawn, forged or cast steel. The development of the gouging process has resulted from a growing need for special oxyacetylene equipment for removing weld metal from the underside of electric arc welds, and for removing weld defects revealed by visual, X-ray, or gamma-ray examination—operations normally involving a great deal of chipping with pneumatic hammers.

Successful application of the process to this type of work soon led to its use in many new operations and its subsequent expansion into new industrial fields. At the present time the use of the gouging process can be traced to many diversified applications other than the original steel fabricating industry, namely, machinery manufacturing, oil refineries, steel foundries, shipyards and other industries, besides any number of maintenance operations in all types of plants. With gouging still in its infancy, the following discussion of current applications will undoubtedly suggest many additional uses for the process.

The basis of the gouging process depends upon the design of a special nozzle to deliver a relatively large volume of oxygen at low jet velocity. This jet, coupled with proper preheat flame distribution, and guided by a simple gouging manipulation, will cut a smooth, accurately defined groove in the surface of steel plate. By using different nozzles and manipulations, the groove can be varied in width and depth at the will of the operator.

The process is somewhat similar to that of hand-deseaming, the principle difference being that the degree of accuracy of metal removal with a gouging blowpipe is considerably greater than that with a deseaming blowpipe. In conditioning steel billets and slabs by deseaming, the primary object is to remove a wide, shallow layer of metal, thus eliminating surface defects and leaving the resulting surface prepared for subsequent rolling operations. Gouging, with its characteristic U-shaped groove contour, removes the required surface metal while preparing a groove which is properly shaped for welding operations.

Operators can grasp the gouging technique and qualify for processing the normal run of gouging applications with a minimum of instruction. Usually, with a little experience, the operator can handle many more difficult jobs with confidence. In general gouging applications can be classified in four groups. These consist of the following:

1. Progressive gouging of the underside of electric arc welds.
2. Spot-gouging in the removal of defective weld metal and temporary tack-welds.
3. Plate-edge preparation for welding.
4. Maintenance and scrapping operations.

Applications of these four groups will be discussed in the order named.

*Presented before the 40th Annual Convention, International Acetylene Association, Milwaukee, Wisconsin, April 10, 11 and 12, 1940.

†Service Engineer, The Linde Air Products Company, Chicago, Ill.

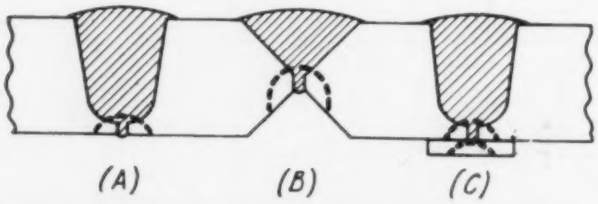



Fig. 1—Conventional Weld Designs. The Dotted Lines Indicate the Metal Removed by Gouging. (*A*) U-Groove Preparation; (*B*) Double-Vee Preparation; and (*C*) U-Groove Preparation with Backing-Up Strip. Original Weld Deposits Are Shown by Cross-Hatched Areas

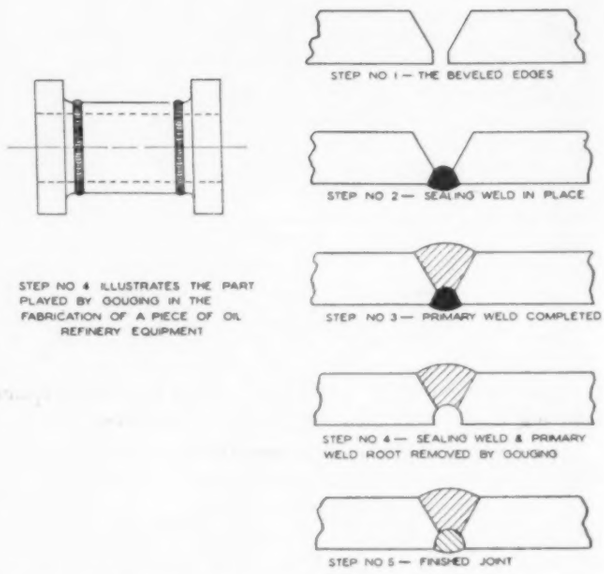

STEP NO 1 — THE BEVELED EDGES
STEP NO 2 — SEALING WELD IN PLACE
STEP NO 4 ILLUSTRATES THE PART PLAYED BY GOUGING IN THE FABRICATION OF A PIECE OF OIL REFINERY EQUIPMENT
STEP NO 3 — PRIMARY WELD COMPLETED
STEP NO 4 — SEALING WELD & PRIMARY WELD ROOT REMOVED BY GOUGING
STEP NO 5 — FINISHED JOINT

Fig. 2—These Sketches Show a Typical Gouging Application in the Fabrication of a Piece of Oil Refinery Equipment

## GOUGING THE UNDERSIDE OF ELECTRIC WELDS

Welding codes and general practice in most plants where steel vessels, tanks and other welded structures are fabricated, require the removal of the root of the initial weld before the back weld is made. This is done so that conditions for highest weld quality are provided when the final weld is made. This was one of the major applications for which the gouging equipment was developed, and many field trials bear out laboratory tests to prove that gouging is not only much faster, but also considerably more economical than other methods of weld-metal removal.

As an example, a recent survey made in a shipyard which has adopted gouging as standard practice for removing the reverse side of electric arc welds, shows a 60

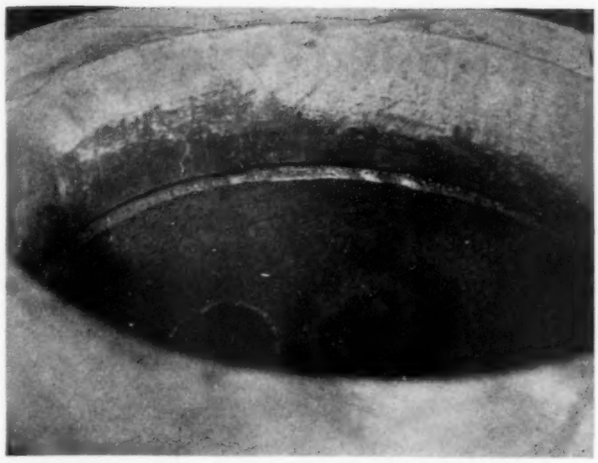


Fig. 3—This View of the Operation Sketched in Fig. 2 Shows the Finished Groove Prepared by Gouging

per cent direct savings in labor and material costs compared to those of the chipping process which was replaced. Furthermore, it was revealed that the average gouging operator can process four to five times more lineal footage of weld seam than the average chipper can in the same time.

Figure 1—*A* shows the conventional U-groove preparation in weld design. The section enclosed by dotted lines is removed by gouging, brushed free of slag, and then electric arc welded. The usual double-vee preparation is indicated by *B*. Here, the same procedure is followed as in *A*, the only difference being the type of weld design. *C* shows the procedure used when a backing-up strip is used to aid penetration in the initial weld. Two passes are required, one to remove the backing-up strip, and the other to remove the weld root as described in *A*.

Figure 2 shows a typical gouging application in the removal of the underside of welds. In oil refinery construction, certain special service piping members must be fabricated. A specific example is a short length, heavy-walled, fabricated pipe section shown in the sketch. This pipe assembly consists simply of a length of heavy-walled steel pipe to which is welded special flanges. The construction specifications require the joint preparation and welding steps shown at the right in the order in which they are performed. Here the gouging process is used to remove the sealing weld—an operation performed in an area difficult to reach by any other method. Figure 3 is a photograph of the completed gouge on the underside of the welded joint described in Fig. 2, showing the groove prepared for the final welding operation.

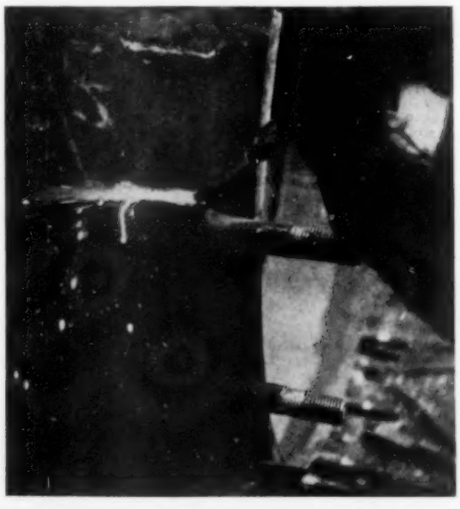
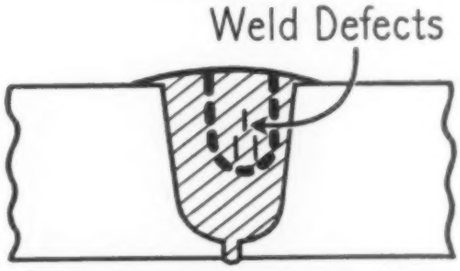


Fig. 4—This Close-Up Shows the Gouging Blowpipe Being Used to Remove Welded Studs

## REMOVING WELD DEFECTS

The removal of weld metal such as weld defects, temporary welds, and tack-welds, are classified under the title of "spot-gouging." In this type of work, the need for positive control of the cutting action is of major importance. The gouging operator can quickly and accurately remove the spots or areas of metal which X-ray, gamma-ray or visual inspection designate for removal. Figure 4 is a close-up of an operator removing threaded studs from the surface of a large-diameter fabricated pipe, without cutting into the surface of the steel pipe. These studs were temporarily welded to the pipe for holding end plates in position in order to perform a hydrostatic test on the fabricated shell. Here, the removal operation performed by gouging took approximately 2 min. per stud, while the former method of chipping required 21 min. to accomplish the same work.

Fig. 5—Weld Defects Are Readily Removed by Gouging as Indicated by the Dotted Line



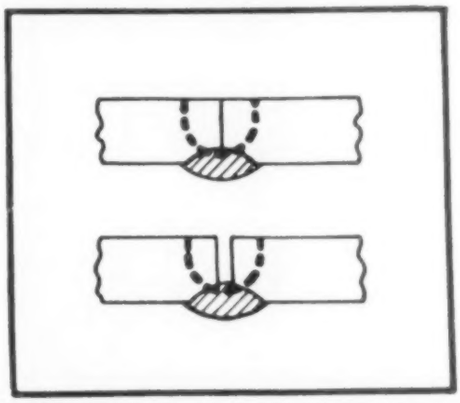



Fig. 6—Dotted Lines Indicate the Amount of Metal Removed in the Preparation of Butted Plate Edges for Welding

In the modern fabricating shop doing the class of work upon which X-ray or gamma-ray inspections are standard practice for checking weld quality, the gouging blowpipe again proves to be a valuable tool. Figure 5 shows a typical weld design in which patches of porosity or inclusions are indicated. The dotted lines enclose the area of metal which is removed by the gouging process. The cutting action is controlled to cut just deep enough to remove the unsound metal. In this operation the blowpipe is not moved forward as in progressive gouging, but is manipulated to remove only the minimum of weld metal possible, and still eliminate the weld defect. The resulting narrow gouge slopes sharply downward from the surface of the plate from each end, effecting conditions of highest economy for repairing the weld.

## PLATE-EDGE PREPARATION

A gouging application which is gaining in importance is the preparation of plate edges for welding. Three types of edge preparation are employed. First is the full U-grooving of abutting plate edges. Second is the J-grooving of a single edge for plate thicknesses up to $1^1/_4$ in. in thickness. Third is the U- or J-grooving of heavy plate thicknesses above $1^1/_4$ in. in thickness by a combination of beveling and gouging. It should be mentioned that concentric rivet-cutting nozzles and other low-velocity-oxygen nozzles have also been found useful for edge preparation, particularly on plate of heavier thicknesses.

Figure 6 illustrates a speedy and economical method for preparing simultaneously two butted plates for welding. The plates are butted or spaced apart as shown and a single bead welded down the seam. The dotted portion is then removed by gouging, to form a clean U-groove for welding with a backing-up bead in place. The initial bead may or may not be removed later. An excellent job can be made by hand in preparing joints of this type in plate up to $^3/_4$ in. thick.

An example of savings gained by using this type of weld preparation is illustrated by a fabricator of small tanks. Each tank measured 8 ft. long by 6 ft. in diameter, with approximately 25 ft. of seam to be welded. The wall

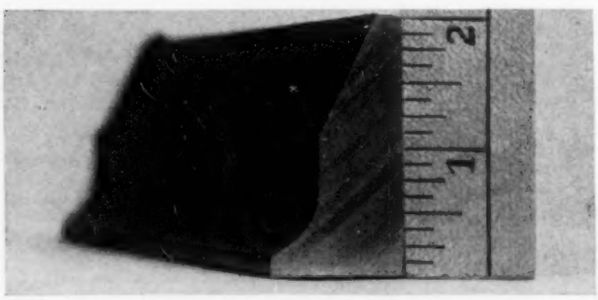


Fig. 7—This Close-Up Shows the Edge Contour of 2-In. Plate Prepared for Welding by a Combination Beveling and Gouging Technique

thickness was $^3/_8$ in. The gouging operator prepared the edge which had been butted together as shown in Fig. 6 with a single pass of the gouging blowpipe. He averaged 30 min. to process each tank as compared to a 6-hr. chipping time.

Joint design specifications often require a U- or J-edge preparation for welding on plate in the heavier thicknesses in preference to the vee-edge preparation. In order to provide clearance for the electrode at the bottom of the vee, an angle would have to be selected which would require an excess of weld metal. In order to gain the economies of the oxyacetylene process for preparation of plate edges on heavy plate thicknesses, a combination bevel and gouge technique has been developed. Figure 7 shows the resulting edge contour. The bevel-cut is made first, and then clearance for the electrode is obtained by a second gouging pass.

This process is entirely mechanized, and the quality of the flame-machined surfaces is exceptionally high. Figure 8 shows the mechanical set-up in action while making the second or gouging pass. One particular fabricator uses this preparation for welding 40-ft. long Diesel-locomotive frames with appreciable savings in time and expense.

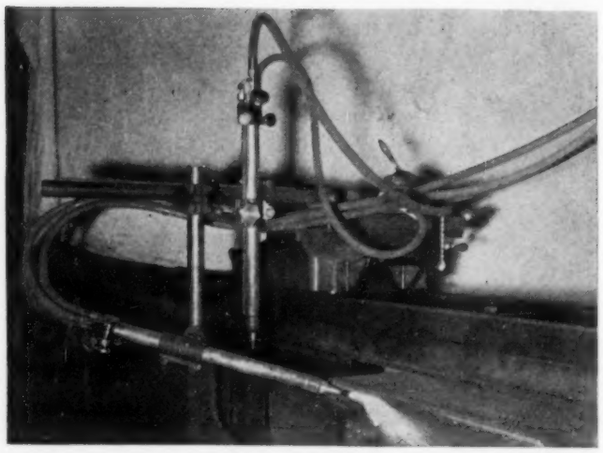
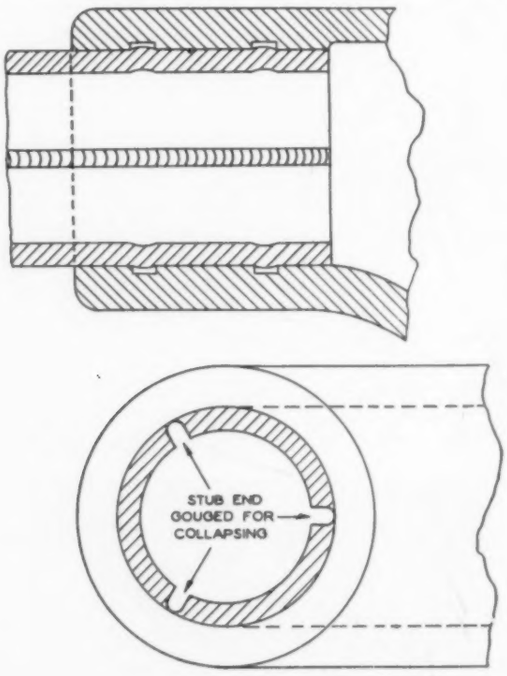


Fig. 8—This Heavy Plate Is Being Prepared for Welding by Gouging. The Plate Has Already Been Beveled. Here, the Gouging Blowpipe Is Making the Second Pass to Give an Edge Contour Similar to That Shown in Fig. 7

## MAINTENANCE AND SCRAPPING APPLICATIONS

Another application of importance in which the gouging process has found immediate acceptance is in the field of maintenance and repair operations. The

Fig. 9—The Removal of "Stub Ends" Without Injuring Header Castings Makes Gouging a Valuable Process in Still-Tube Replacement Work in Oil Refineries



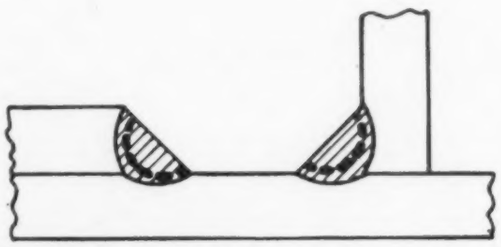



Fig. 10—Dotted Lines Enclose the Metal Removed in Gouging Fillet Welds in Scrapping Operations on Welded Structures

**Table I—Operating Data for Gouging Nozzles**

| Nozzle No. | Regulator Pressure,* Lb. per Sq. In. | | Consumptions, Cu. Ft. per Hr. | | | Approximate Speed Ft. per Min. | Approx. Gouge Dimensions, In. | |
|---|---|---|---|---|---|---|---|---|
| | Acetylene | Oxygen | Acetylene | Preheat Oxygen | Cutting Oxygen | | Width | Depth |
| 13 | 10 | 65 | 35–38 | 35–38 | 78– 82 | 1.0–1.2 | 5/16 | 1/8 –3/16 |
| 13 | 10 | 70 | 35–38 | 35–38 | 88– 92 | 1.4–1.6 | 5/16 | 5/32–7/32 |
| 13 | 10 | 75 | 35–38 | 35–38 | 98–102 | 1.5–1.8 | 5/16 | 3/16–1/4 |
| 19 | 10 | 80 | 50–55 | 50–55 | 170–175 | 1.6–1.9 | 3/8 | 3/16–1/4 |
| 19 | 10 | 85 | 50–55 | 50–55 | 188–192 | 1.8–2.0 | 7/16 | 7/32–9/32 |
| 19 | 10 | 90 | 50–55 | 50–55 | 205–210 | 1.9–2.2 | 7/16 | 1/4 –3/8 |
| 25 | 10 | 90 | 55–60 | 55–60 | 278–282 | 1.9–2.2 | 1/2 | 3/16–1/4 |
| 25 | 10 | 95 | 55–60 | 55–60 | 308–312 | 2.3–2.6 | 1/2 | 1/4 –3/8 |
| 25 | 10 | 100 | 55–60 | 55–60 | 328–332 | 2.5–2.8 | 1/2 | 5/16–7/16 |

* Pressures measured ahead of 12 1/2 ft. of 3/16-in. hose in series with 25 ft. of 3/8-in. hose. Nozzles can also operate on low-pressure acetylene.

importance of rapidly repairing and restoring to operation a piece of machinery which has broken down is a major factor in maintenance work. The welding processes were a particular boon for this type of work. Now, gouging complements the welding process to reduce the time still further.

Figure 9 illustrates an interesting oil refinery problem. This refinery replaces an average of 200 still tubes per month. These tubes are rolled into header castings as shown in the sketch. The standard practice was to oxyacetylene-cut the tube close to the header castings and then remove the 4-in. to 5-in. long "stub end" with hammer and cold chisel. This procedure was followed so that no possibility of damage to the header casting was likely to take place. All stubs are now being removed by gouging. The tubes are cut off as before, and then three grooves, as indicated in the sketch, are gouged the length of the stud. The cutting is controlled so that it will carry only deep enough to collapse the tube, but not cut into the casting. Following the gouging operation the stubs easily fall out, the total process now being reduced to 5 min. per stub.

The processing of steel castings by gouging is becoming increasingly more important. A steel foundry in Philadelphia presents a typical example of this work. A 12-ton rectangular steel section was recently cast by this firm. The surface of the casting in contact with the mold was covered with sand scabs and other defects. It was estimated that three days would be required to clean the casting by chipping with a pneumatic chisel. A small portion of it was cleaned in this manner. A gouging operator was put on this job and went over the cleaned portion again, and it was proved to the plant foreman that the chipping operation peened the metal over the defective areas with the result that large sand inclusions remained. The total time for the gouging operation took 3 hr. to prepare the casting completely for repairing by welding.

The ability of the operator using the gouging blowpipe to cut to close tolerances without damaging the base metal is of great value in scrapping operations. Welded structures can be dismantled quickly by merely gouging through the welds. The plate thus salvaged can be prepared for re-use by oxyacetylene machine-cutting. A New Jersey junk dealer salvages the plates from steel barges at considerable profit by using this cutting method. Figure 10 shows the gouging cuts for removing fillet welds in this type of work.

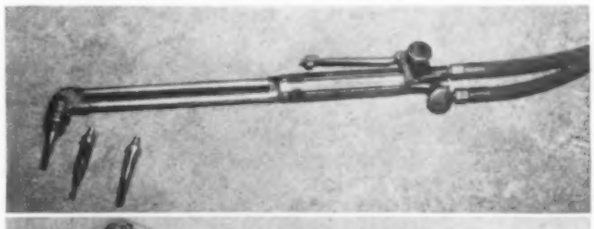
The foregoing applications are only a few of the typical jobs accomplished by the gouging process and doubtless other applications already suggest themselves.

## GOUGING APPARATUS

Figure 11 shows a standard hand-cutting blowpipe and gouging nozzles. These nozzles, besides fitting standard blowpipes with 75 and 90 deg. heads, also can be used with a special 180-deg., straight blowpipe designed for gouging only. It has been observed that new operators unfamiliar with all phases of oxyacetylene cutting can grasp the gouging technique more readily if trained to use the straight blowpipe. Experienced cutting operators usually prefer the 75- or 90-deg. blowpipes. They have found that they can operate these blowpipes skillfully with only a slight modification of the hand-cutting technique.

Figure 12 shows a close-up of the gouging nozzles. The three sizes are Nos. 13, 19 and 25. They are designed to operate with either medium- or low-pressure acetylene. The nozzles are bent to provide clearance for the blowpipe body, and to give better balance to the apparatus. A Haynes Stellite alloy skid protects the bottom of the nozzle from abrasion received during the gouging operation.

Fig. 11—Gouging Operations Are Performed with a Series of Three Special Nozzles Designed for Use with Standard Cutting Blowpipes



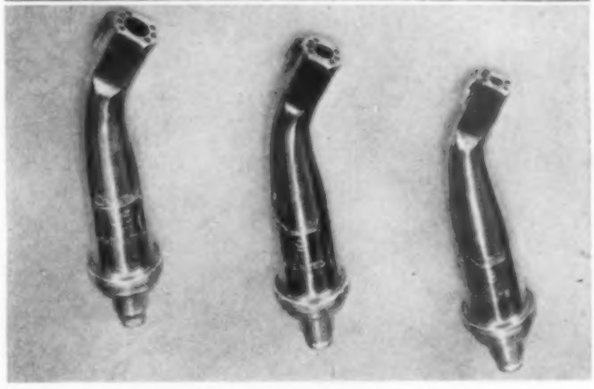


Fig. 12—This Close-Up of the Three Gouging Nozzles Shows Details of Their Construction

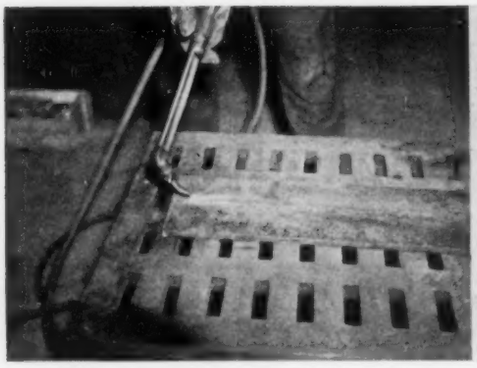


Fig. 13—During Preheating, the End of the Nozzle Should Form an Angle of 20 Deg. with the Line of Cut

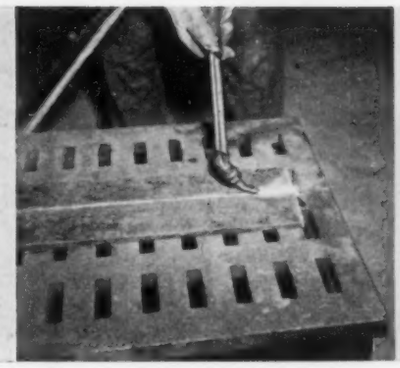


Fig. 14—While the Cut Is Progressing, the Angle Between the End of the Nozzle and the Work Should Be Reduced to About 5 Deg.

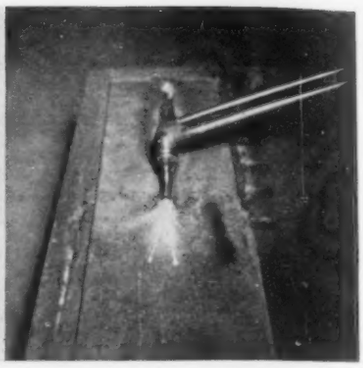


Fig. 15—This Close-Up, Looking Along the Line of Cut, Illustrates the Gouging Operation

## GOUGING TECHNIQUE

There are, in general, two different techniques for gouging: one in which a groove is made progressively across a plate, as in the removal of metal from the underside of welds; the other, known as spot-gouging, in which a small area is gouged out, as in the removal of isolated weld defects. In the first or progressive method, the correct nozzle is selected and oxygen and acetylene pressure regulated to give the desired width and depth of groove as indicated in Table 1.

In starting the cut, the blowpipe is held with the end of the nozzle at an angle of approximately 20 deg. to the horizontal and above the line of cut as shown in Fig. 13. The preheat flames are played on the spot where the cut is to be started until the surface reaches the ignition point. The cutting-oxygen lever is then gradually depressed. The cut progresses slowly while the angle of the end of the gouging nozzle is gradually reduced to the correct operating position. This angle, as illustrated in Fig. 14, will be readily discernible by the operator. If the nozzle is not lowered far enough, some of the slag will tend to flow backward in the cut toward the operator, while if the blowpipe is lowered too far, the groove will become shallow and will soon be lost. Figure 15 shows a close-up view of the operation in progress.

In starting the gouge, the blowpipe is held so that the tips of the inner cones of the preheat flames are just touching the work. After the cut is started, however, the nozzle is held above the surface of the cut, with the tips of the inner cones from $^1/_4$ in. to $^1/_2$ in. back of the reaction zone. Best results are obtained when the blowpipe is held so that the nozzle clears the bottom of the groove.

When it is necessary to change the direction of the cut, the angle of the nozzle in relation to the work should remain unchanged while the blowpipe is rotated in the new direction. Too sharp turns should be avoided lest the outside wall be cut into as the result of the action of the molten slag. It is advisable to use lower cutting-oxygen pressures than those indicated in Table 1 when not cutting in a straight line.

## CONTOUR OF THE GROOVE

The depth of the groove is a function of the speed of progression and the angle between the cutting-oxygen stream and the work. To cut a deep groove, the angle of the blowpipe is increased in relation to the groove, and the speed is correspondingly decreased. In order to make a shallow groove, the procedure is reversed. With the establishment of the correct depth of cut, it is an easy matter to maintain this depth throughout the full length of the cut. Grooves can be made that are as deep as or slightly deeper than they are wide.

The contour of the groove is dependent upon the characteristics of the nozzle used and the operating conditions. If the cutting-oxygen pressures are too low, the cutting takes on a washing effect, leaving ripples in the bottom of the groove. The effect of too high cutting-oxygen pressures is to advance the portion of the cut nearest the surface ahead of the rest of the molten zone, with the result that the cut is finally lost.

## SPOT-GOUGING TECHNIQUE

In gouging out a spot, such as a single weld defect, the defect is first marked out on the surface of the weld. A starting point is next selected a little to the rear of the mark, depending on how deep the defect is judged to be. The cut is then started in the usual manner by preheating the spot, but instead of reducing the angle of the nozzle, it is increased gradually so that the oxygen jet is directed downward, making the cut increasingly deep. As in deseaming, a little experience enables the operator to observe readily any defects which appear as dark spots in the molten zone.

The blowpipe should be held so that the tips of the inner cone flames are about $^1/_{16}$ in. above the plate surface at all times during the cut. The nature of the resulting cut is a narrow U-shaped groove which can readily be filled with weld metal.

The A. S. M. E. Boiler Construction Code in Sections S-1, S-2 and S-26, which apply to specifications on plate used for boilers and pressure vessels, includes high-tensile-strength carbon steel plates of 2 in. and under in thickness, having a maximum carbon content of 0.35 per cent. This code is similar to A. S. T. M. and A. P. I. codes covering like material. Steels of this type, having carbon content of 0.35 per cent or under, can be processed with the gouging blowpipe with excellent results.

As a general rule, gouging should not be applied to air-hardening steels where the hardness will be objectionable. For example, clips should not be removed from the surface of a vessel where the carbon content of the plate is so high as to cause the formation of a hardened zone having decreased ductility.

Care should be used in gouging alloy steels. Test cuts should first be made in scrap pieces and the operator should determine from these cuts whether the characteristics of the metal about the cut have been altered too drastically.

# MACHINE FLAME CUTTING*

By H. C. BOARDMAN†

OXYACETYLENE cutting of ferrous metals is a process of preheating the material to be cut to its kindling or ignition temperature and rapidly oxidizing it by means of a closely regulated jet or stream of oxygen issued from a special tool called a cutting blowpipe or torch. The process is therefore primarily a chemical one, based on the remarkable chemical affinity of oxygen for ferrous metals which have been raised to or above the kindling temperature. In addition, there is a noticeable and helpful mechanical eroding effect produced by the kinetic energy or motive power of the cutting oxygen stream. This washes away considerable of the molten metal in unconsumed or metallic form, thereby adding to the efficiency and economy of the process. Only the metal within the direct path of the oxygen jet is acted upon, so that remarkable accuracy is possible where close control is exercised.

*History*

The cutting of steel, raised to kindling temperature, by means of an oxygen jet apparently was first discovered by Thomas Fletcher, about 1887, but the first practical blowpipe or torch which combined the preheating and cutting operations was not developed until 1901. The process was introduced in the United States about 1907.

*Industrial Status*

Even in the short period of time which has elapsed since its advent, oxyacetylene cutting has wrought profound changes in industrial practices pertaining to the shaping of steel. Formerly the severing, cutting or machining of ferrous metals could be accomplished only by shearing, sawing, turning, planing, milling, nibbling or other mechanical means, at the expense of considerable power, or by laborious and time-consuming hand methods.

The ease and economy with which much of this work is done today by oxyacetylene cutting is nothing short of revolutionary. Being free-running, with reference to the production of a cut, the cutting torch or blowpipe does not engage or contact the work at any time during the cutting operation. Therefore, no power is required, except a nominal amount for moving the cutting torch and its holder over the work. This applies to both light and heavy cuts. Very heavy sections, heretofore uneconomical to cut by any of the mechanical cutting processes, are readily and smoothly cut by the oxyacetylene process, the limits of which apparently as yet have not been approached.

Oxyacetylene cutting has created what may be termed a new industry, devoted to the fabrication of flame-cut and shaped rolled steel for heavy machinery and equipment—their bases, housings and frames. This, in turn, has extended and enlarged the commercial horizon of the lower-priced heavy steels, increased fabricating speed and eliminated many costly shaping and finishing operations. Today, oxyacetylene cutting is as essential to the art of metal working as any of the allied processes which shape or otherwise prepare unfinished ferrous metals for industry. It constitutes one of the major tools employed.

The extremely low initial cost of oxyacetylene cutting apparatus, as compared with mechanical cutting devices capable of performing similar work, has won a very important place for the process in both large and small shops. Particularly the smaller establishments are now able, through its use, to undertake a great variety of jobs on materials considerably heavier and more intricate in shape than were formerly within their capacity. A noteworthy expansion of their business has resulted.

In machine cutting, where the torch is held firmly and advanced at uniform speed, cross-cut tolerances can be kept within narrow limits. For example, in ordinary steel of 6-in. thickness, the cut surfaces can be held true as to cross-sectional squareness to within $^1/_{32}$ in. or less. Cuts in thinner sections can be held true to within proportionately smaller limits. In fact, machine cuts can be made so smooth and square and have such sharp edges that in many cases they require no further finishing of any kind.

*Chemistry*

It was stated at the outset that oxyacetylene cutting is primarily a chemical process. The chemical formulas involved are as follows:

$$\text{Primary } C_2H_2 + O_2 = 2CO + H_2$$

$$\text{Secondary } \begin{cases} 2CO + O_2 = 2CO_2 \\ H_2 + {}^1/_2O_2 = H_2O \end{cases}$$

It will be noted that the combustion of the acetylene in the preheating flames takes place in two stages. In the primary combustion in the inner flame cone, 1 volume of acetylene ($C_2H_2$) combines with 1 volume of oxygen ($O_2$) (supplied to the blowpipe) to form 2 volumes of carbon monoxide (CO) and 1 volume of hydrogen ($H_2$). In the secondary combustion in the envelope flame, the 2 volumes of carbon monoxide (CO) combine with 1 volume of atmospheric oxygen ($O_2$) to form 2 volumes of carbon dioxide ($CO_2$), and the 1 volume of hydrogen ($H_2$) combines with $^1/_2$ volume of atmospheric oxygen ($O_2$) to form 1 volume of water vapor ($H_2O$). Therefore, a total of $2^1/_2$ volumes of oxygen are required for the complete combustion of 1 volume of acetylene.

The oxide of iron formed in oxyacetylene cutting is a

---

* Annual International Acetylene Association Lecture presented at the 40th Annual Convention of the International Acetylene Association, April 10, 11 and 12, 1940, Milwaukee, Wisconsin. This paper was prepared with the cooperation of Mr. E. V. David, Air Reduction Sales Company, Mr. J. H. Zimmerman, The Linde Air Products Company and other members of the Oxy-Acetylene Committee of the International Acetylene Association.

† Research Engineer, Chicago Bridge and Iron Company, Chicago, Illinois.

Fig. 1—A Typical Round Cutting Application Showing Control of the Blowpipe Position by Means of a Roller Support

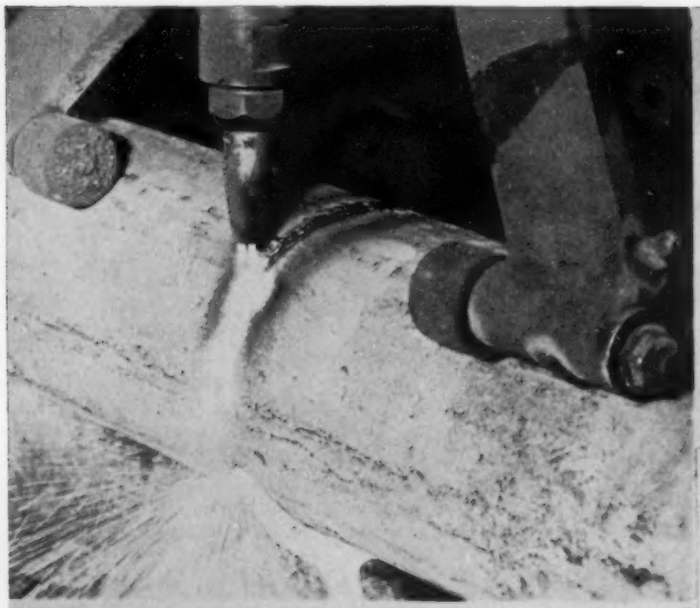


Fig. 2—Cutting 28 x 36-In. Riser in Heavy Half-Flywheel Steel Casting

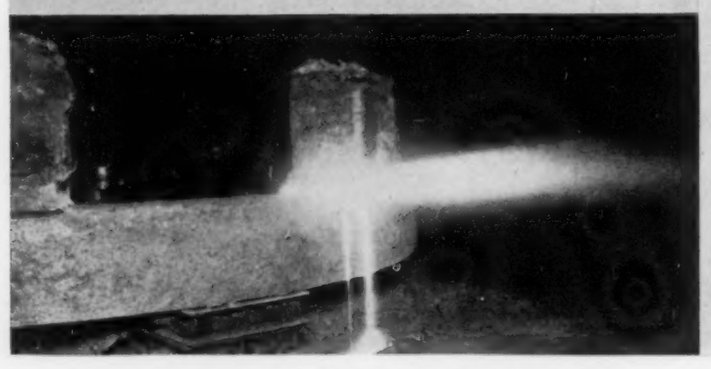


Fig. 3—A Small Portable Billet Cut-Off Machine Application

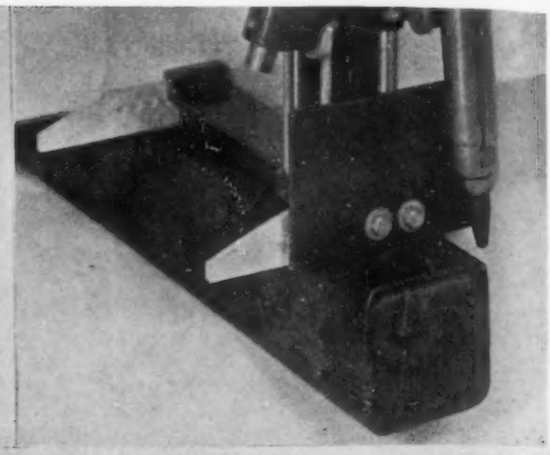
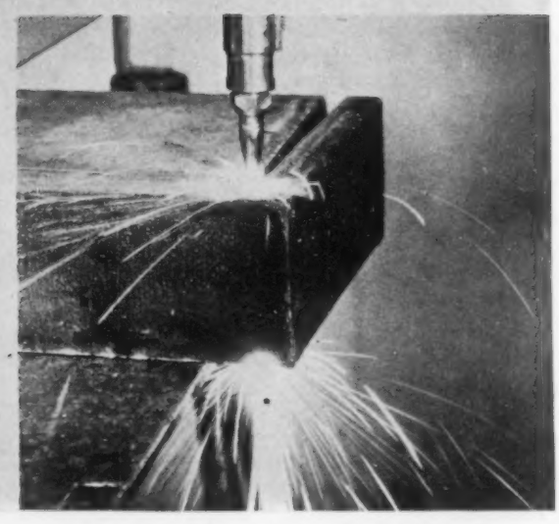


Fig. 4—A Typical Straight-Line Cutting Application



black, brittle substance, identical in composition with hammer scale or magnetite ore. Its chemical formula is $Fe_3O_4$. This latter substance contains a smaller proportion of oxygen than rust or red iron oxide ($Fe_2O_3$). The completed equation for the oxidation reaction in oxyacetylene cutting is:

$$3Fe + 2O_2 = Fe_3O_4 + 26{,}691 \text{ calories}$$

In other words, three atoms of iron (Fe) combine with two molecules of oxygen ($O_2$) to produce one molecule of magnetite ($Fe_3O_4$). In this oxidation reaction, 1593 calories per gram, or 2870 Btu. per lb. of iron, are produced, which represents the calorific energy of the iron. As the atomic weight of iron (Fe) is 55.84 and the molecular weight of oxygen ($O_2$) is 32, it follows that the relative weights of the iron and the oxygen in magnetite ($Fe_3O_4$) are as 167.52 is to 64.00, or as 2.618 is to 1. Therefore, 1 lb. of oxygen will oxidize or consume 2.618 lb. of pure iron. As oxygen at 70° F. and 1 atmosphere pressure has a volume of 12.07 cu. ft. per lb., and pure iron weighs 0.285 lb. per cu. in., it can be computed that 1 cu. ft. of oxygen will oxidize 0.217 lb. or 0.761 cu. in. of pure iron.

## CUTTING TECHNIQUE

Satisfactory commercial oxyacetylene cuts must fulfill the following requirements:

1. A sufficiently short drag; that is, the line markings on the face of the cut should approach the straight up-and-down condition.
2. The sides of the cut should be sufficiently smooth; not grooved, fluted or ragged.
3. There should be no firmly adhering slag on the bottom of the cut, as this requires an appreciable expenditure of labor for its removal. With proper adjustments, only loose slag or none at all is obtained.
4. The upper and lower edges of the cut should be sufficiently sharp to meet the requirements of the particular job.
5. The cost must be moderate.

To produce satisfactory commercial oxyacetylene cuts the following conditions must be maintained:

1. Suitable cutting tip, with correct-size cutting orifice and proper degree of preheat.
2. Proper oxygen and acetylene pressures.
3. Correct cutting speed.
4. Uniformity of torch movement.
5. Uniform oxygen and acetylene pressure regulation.
6. Smooth and uniform bore and proper type of cutting orifice.
7. Cleanliness of cutting orifice exit.
8. Cleanliness of preheat holes; end of tip must be kept free from adhering slag.

9. High purity oxygen.
10. Proper angle of incidence of the cutting oxygen stream to the upper edge of the work.

*Selection of Cutting Tip or Nozzle*

A wide variety of cutting tips or nozzles is available. These provide for cutting various thicknesses of most ferrous materials and for different surface conditions, such as clean, painted, rusty or scaly surfaces, as well as for a variety of special types of work. The thickness of the material to be cut governs the diameter of the cutting orifice of the tip to be selected. The condition of the surface and composition of the metal determine the intensity of preheat flames which should be used. Rusty or scaly surfaces often are cleaned or "descaled" along the line of cut before cutting, by cracking the scale loose, either with the torch preheating flames or mechanically, with scrapers or chipping hammers.

*Starting Cuts*

In most cases, cuts are started at the edge of the piece. The cutting torch is held so that the ends of the preheating flame inner cones just clear the surface of the material. When a spot of metal at the top of the edge has been heated to a bright red, the cutting oxygen jet is turned on. The metal in the immediate path of the cutting jet oxidizes and, as the torch is moved steadily along the line to be cut, separation is effected. In machine flame cutting ordinary steel, the tip should be adjusted vertically at a correct distance above the surface of the work and advanced at the proper speed.

*Piercing Holes*

In starting a cut in the metal away from the edge, or in piercing a hole, more time usually is consumed in bringing the spot to the kindling temperature than with edge starting. When a spot has been heated to a bright red, the torch is raised to about $^1/_2$ in. above the normal height for line cutting, and the cutting oxygen turned on slowly. As soon as the work is perforated, the torch is lowered again to the normal position above the work and any further cutting that may be required is carried on. Drilled holes are used for certain work, particularly to form a straight, smooth starting edge for a heavy internal cut.

*Cutting Rounds*

When cutting round bar steel, gas pressures are set for the maximum thickness or diameter and the cut is started at the side. As the cut progresses, provision is made to raise the torch to follow the circumference. A typical set-up is shown in Fig. 1. Starting cold cuts is facilitated by nicking the round with a chisel to create a burr at the point where the cut is to begin, to enable the oxygen to take hold more easily.

*Heavy Cutting*

In heavy cutting, as illustrated in Fig. 2, the greatest care must be exercised in selecting the proper operating pressure. Not only is the range of suitable pressures considerably narrower for the heavier cuts, but the loss in pressure through the hose line connections and the blowpipe or torch becomes rapidly larger with the increasingly greater oxygen flows demanded for heavy cutting. Variations in the quality of the steel are also more important in the case of heavy cutting.

Quite a little skill sometimes is needed in starting a heavy cut so as to sever completely the initial lower corner and to avoid pocketing of the cutting oxygen stream in the lower portion of the cut. It is essential that the front edge of the cut be very clean, particularly the lower portion of the front face. The axis of the tip should be aligned with the front edge of the material by turning on the cutting oxygen stream with preheating flames burning, to render it visible.

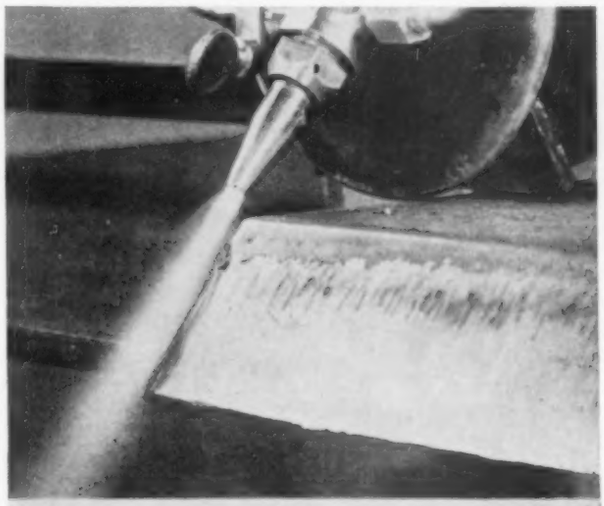
In starting the cut, the movement of the blowpipe or torch should be retarded just long enough to allow the cutting oxygen stream to attack the material actively throughout almost its entire depth. Then the torch is permitted to proceed normally. If the piece is very heavy, the lower portion of the front face sometimes is heated with a large welding flame. In certain instances, starting is facilitated by first undercutting the forward edge of the material with a hand-cutting torch. Unless done by an experienced operator, however, poor and ragged cuts may be obtained by this method.

Care is often required in completing the final corner of heavy cuts. A slight retardation of the forward movement of the torch or blowpipe is desirable here as well, but this must be properly carried out.

*Billet Cutting*

Square and round bars have been cut manually and with standard machines ever since the introduction of the oxyacetylene process. The popularity of this method of severing in the production forge shop, the steel mill billet yard and on the merchant mill run-off table has warranted the manufacture of special equipment to improve the quality of the cutting and to reduce the time of the operation. The introduction of auxiliary preheat for quick starting and automatic blowpipe manipulation

Fig. 5—A Typical Bevel Cutting Operation



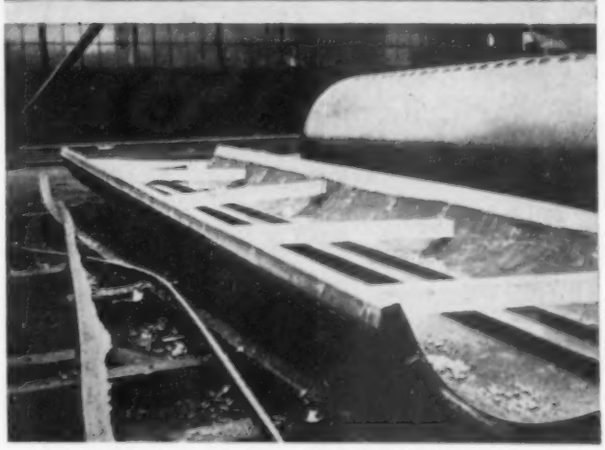


Fig. 6—Flame-Cut Edge on a Rolled Boiler Plate

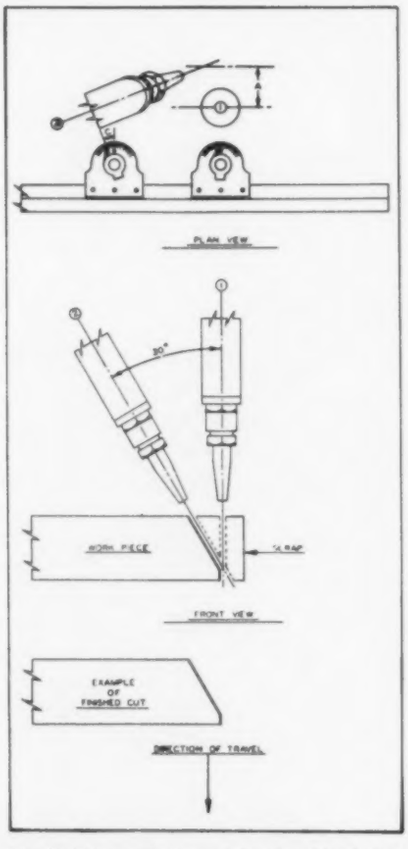



Fig. 7—Schematic Layout for Two-Torch Arrangement to Cut a Single Bevel with a Land

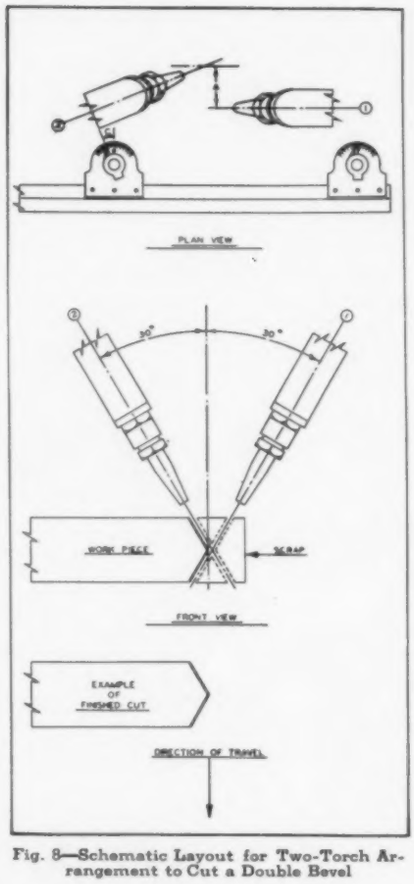



Fig. 8—Schematic Layout for Two-Torch Arrangement to Cut a Double Bevel

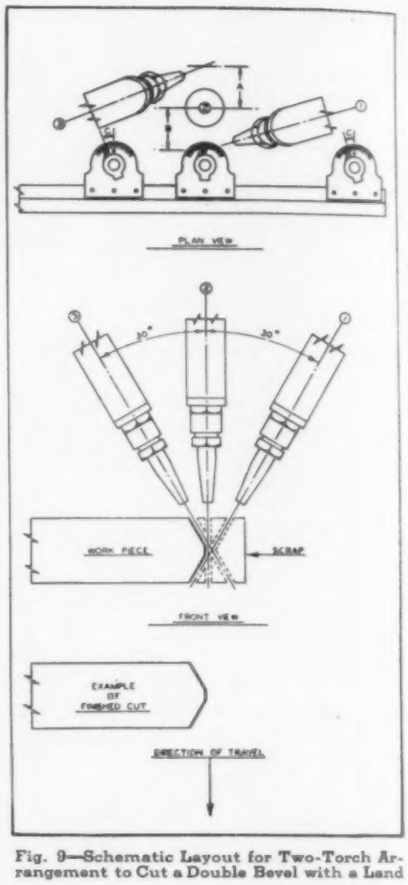



Fig. 9—Schematic Layout for Two-Torch Arrangement to Cut a Double Bevel with a Land

to insure drop-off cuts are features incorporated in the later equipment. One type of portable billet cut-off machine is shown in Fig. 3.

The bars may be cut hot or cold. If cut at 200° F., the speed of cutting may be increased to from 2 to 3 times the cold-cutting speed for the same consumption of oxygen, providing the size of the bar is not greater than 10 in. For larger sizes, increased speeds may be obtained, but the gain decreases as the size increases.

## EFFECTS OF CUTTING

*Metallurgical*

In oxyacetylene cutting, a slight depth of metal immediately adjacent to the cut face is raised to a bright red heat or considerably above the critical range. As the cut progresses, the steel cools again through this range. The speed of cooling is dependent upon the heat conductivity of the surrounding metal, radiation losses and the fact that the heat is applied only momentarily at any given point, the cutting torch being kept in constant motion while cutting. When the steel is being cut at room temperature, the rapidity of the cooling is sufficient to actually have a chilling or quenching effect on the cut edges, particularly in the case of heavier cuts involving large masses of cold metal.

When polished and etched specimens are taken from oxyacetylene cut edges and examined under the microscope, the material is found to be altered, when compared with the original metal. However, the change is largely a physical one, affecting the crystalline grain structure. The normal pearlitic steel is transformed into one or more of several structures, ranging from spheroidized carbides in the ferrite to the harder constituents, depending upon the particular chemical composition of the steel cut and the rate of cooling following the cutting operation. Also, an alteration in grain dimension at the oxyacetylene cut edge is induced, due to the intensity of the heat developed by the cutting. This renders the grains either larger or smaller than the unaffected grain behind the cut edge.

Oxyacetylene cutting on carbon steels, containing less than 0.35 per cent carbon at normal temperatures is not detrimental. Indeed oxyacetylene cut edges of such steels are suitable for any uses where edges prepared by any of the mechanical methods of severing, such as planing, milling, shearing, friction sawing and grinding are employed. Oxyacetylene cut edges are adapted to the applications involving stresses as, for example, mechanical chalking and holes in which tubes are expanded or rivets driven. Clean, smooth oxyacetylene cut edges of low- or medium-carbon steel plates or forgings actually have physical properties that render them superior to sheared, planed or otherwise mechanically prepared edges.

An investigation of the conditions which develop when the fusion-welding process is applied to oxyacetylene cut edges, conducted a few years ago by the A. S. M. E. Boiler Code Committee, produced such conclusive results that all restrictions in the Boiler Code pertaining to welding on oxyacetylene cut surfaces were removed. The wording of the Code requirement, which was adopted in 1935 for incorporation in the Power Boiler and Unfired Pressure Vessel Sections, is as follows:

"Preparation for Welding—The plates may be cut to size and shape by machining or shearing, or by flame-cutting if the carbon content does not exceed 0.35 per cent. If shaped by flame-cutting, the edges must be uniform and smooth, and must be freed of all loose scale

and slag accumulations before welding. The discoloration which may remain on the flame-cut surface is not considered to be detrimental oxidation."

Where edges are oxyacetylene beveled, to form a vee for welding, and later welded together either by oxyacetylene blowpipe or electric arc, the heat of the welding operation acts to dissolve all previously formed marginal structures and anneals the metal for an appreciable depth below the cut surface. Any change in structure that the preceding cutting may have produced in and adjacent to the cut surface is therefore obliterated.

Tests of oxyacetylene cut edges of low- and medium-carbon steels to determine their physical properties, such as hardness, microstructure, resistance to impact and ductility, have shown that they are satisfactory for almost any type or character of mechanical treatment or service.

Oxyacetylene cutting of higher carbon and alloy steels, particularly at room temperature, may produce a thin layer of hard material on the cut surfaces which may not be sufficiently ductile to withstand, without cracking, the stresses set up in cooling or imposed by the subsequent use of the part cut. As the steel is momentarily heated to a high temperature by the torch at the cut edges, it tries to expand, but is restrained by the adjoining cold metal. The action called "upsetting" results. Later, when cooling occurs, contraction of the upset metal may develop severe stresses in tension along the cut edges. With these steels the ductility may not be sufficient to prevent incipient cracks and checks which can prove dangerous in service, as they are apt to develop into large fractures.

*Preheating and Annealing*

Experience has shown that, if these higher carbon and alloy steels are preheated and, in certain cases, annealed or tempered afterward, no cracks will occur on the cut edges. Naturally with the adjoining metal preheated, the difference in expansion between it and the metal heated during cutting is less, and "upsetting" is greatly reduced or eliminated.

Special precautions should be taken in cutting particularly thick preheated sections in order that the work may be done as quickly as possible after the piece has been withdrawn from the furnace. This avoids having the interior considerably hotter than the metal at the surface, which condition may arise if the piece is allowed partially to cool in air before cutting. In the latter case the oxygen jet may start penetration without much difficulty, but upon entering the interior of the section, the oxygen stream may fail to go through and cause a flare-up in the cutting. This stoppage is due to the hot center which oxidizes so readily that a cavity or pocket may form on the inside of the piece. When this occurs, a slight lowering of the cutting oxygen pressure often will be found to clear up the trouble.

To obtain the most efficient use of the oxygen and, at the same time, leave the steel in the best condition, a preheat temperature of 500–600° F. ordinarily should suffice for carbon steels of more than 0.35 per cent carbon. The additional expense that accompanies preheating steel can be cut.

Annealing restores completely the original pearlitic

Fig. 10—A Two-Blowpipe Set-Up with Plate-Riding Device for the Simultaneous Cutting and Beveling of Light Plate

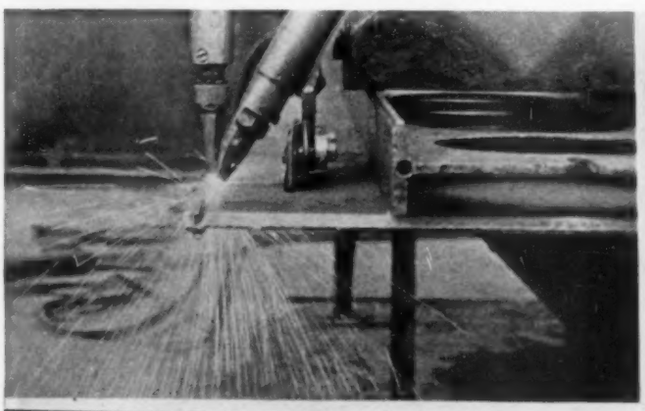


Fig. 11—A Two-Blowpipe Cut and Bevel Operation

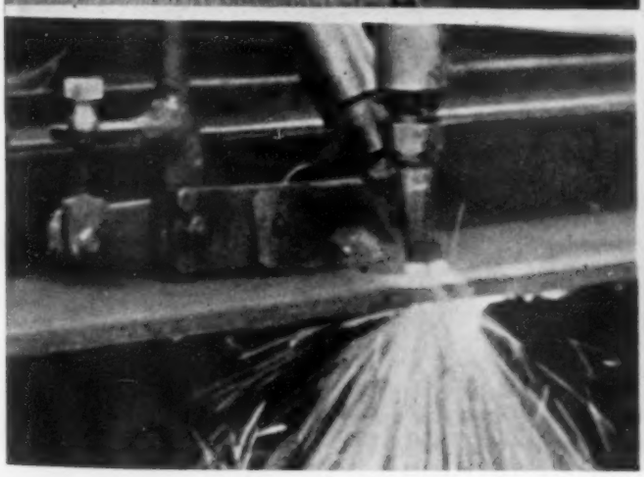
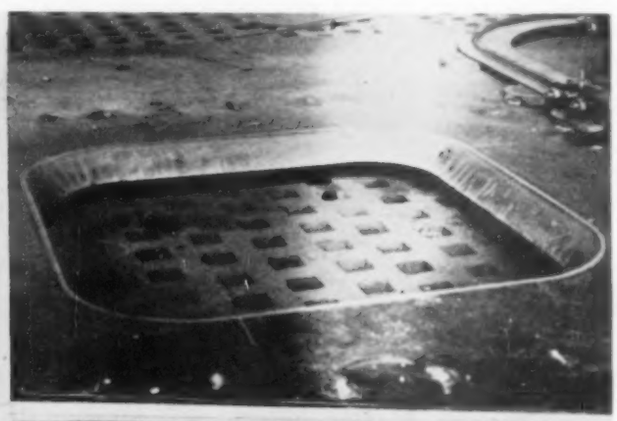


Fig. 12—A 48 Oxyacetylene-Cut Hatch Opening in Deck Armor



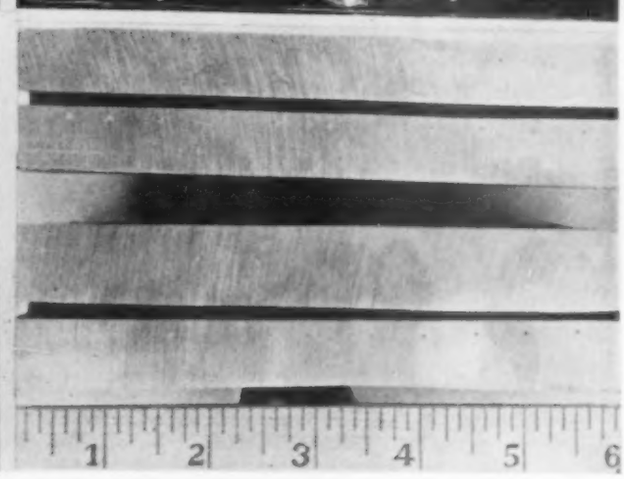



Fig. 13—Parallelism of Flame-Cut Kerfs: (*a*) to Usual Commercial Tolerances, (*b*) a Precision Kerf of Close Tolerance (Top)

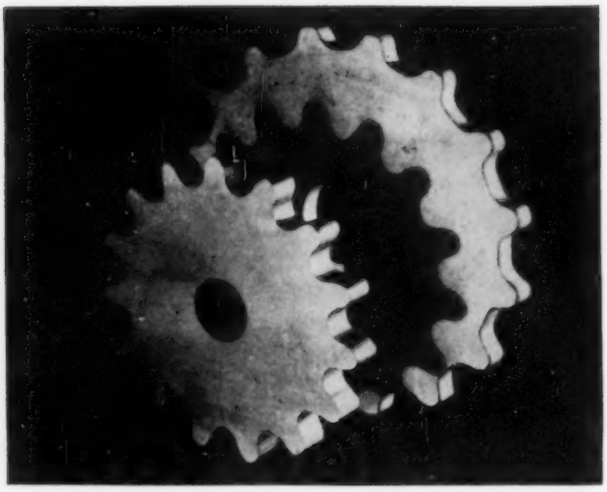


Fig. 14—Machine Flame-Cut Sprockets. Teeth Are So Accurate They Require No Further Finishing

structure of the steel at the cut edges, wherever this may be desired, and removes any internal stresses set up in the metal. If carried out, it should be done immediately after cutting. Annealing temperatures suitable to the type of steel in the piece are employed. These temperatures are ordinarily in the neighborhood of 1250–1450° F. Annealing time depends on the grade of steel, its thickness and shape.

When preheating has been used before oxyacetylene cutting, the majority of steels do not require annealing. This applies to the steels which harden only when rapidly quenched from temperatures above the critical point. However, the air-hardening steels must be annealed or cooled very slowly after cutting, if preheated. The low-alloy, high-strength steels of nickel, silicon and manganese grades are usually in this category. For these it is essential that the postheating does not exceed the critical point.

*Flame Softening*

Flame softening is a localized and progressively applied oxyacetylene heat treatment, similar in its physical aspects to flame hardening, but directly opposed in its objective. The results of flame softening are similar to those obtained by annealing or tempering in a furnace, but the effect can be restricted to a small area and the process is comparatively simple and economical.

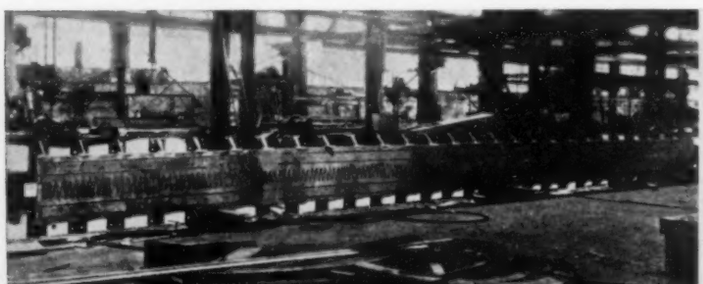
Flame softening can be applied in any one of several ways. In some cases, it is of advantage to preheat the metal locally prior to cutting; in others, the heat treatment is applied after cutting, either directly to the cut surface or to the metal adjacent to the cut. The most effective and economical method depends upon the dimensions and composition of the metal to be treated, as well as upon such factors as the service for which the metal is intended and the results sought.

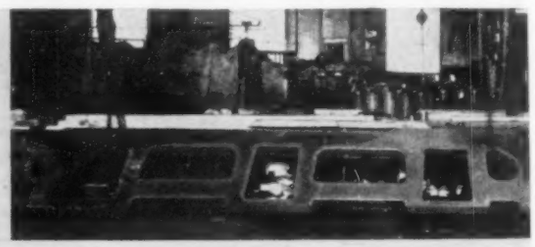
*Mechanical*

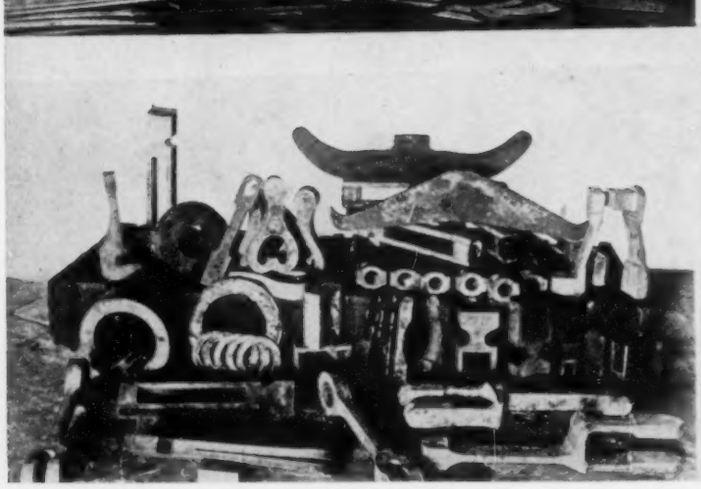
Properly performed oxyacetylene cutting on carbon and low-alloy steels produces accurate results. Top and bottom edges of cuts are sharp and width of kerf uniform. Surfaces of cuts may be smooth and square and

Fig. 17—Flame-Cut Frame Section for Mallet Type Locomotive. (One of Four Cut from Slab 23 Ft. Long, 34½ In. Wide and 5½ In. Thick. Weight of Slab 14,850 Lb. Weight of Frame Section 5000 Lb. Note That Tie Bars Were Left in Jaws of Frame to Be Cut Out Before Machining. Slabs Were Preheated to 600° F. Before Cutting. Seven Starting Holes Were Pierced to Cut Openings)

Fig. 15—Fifty-Foot Viaduct Expansion Joint Machine Flame-Cut to Close Tolerances







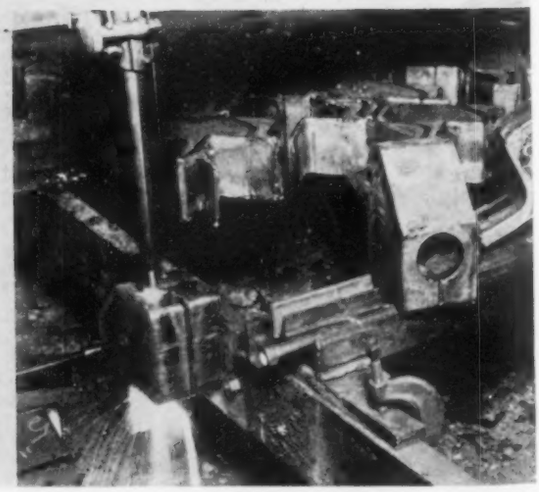


Fig. 16—Representative Assortment of Machine Flame-Cut Parts. (Railroad Parts, Including Radius Bars for Motion Work, Locomotive Cross Equalizer, Crank-Pin Collars, Hub Liners, Brake Rod Jaw, Tender Truck Spring Hanger, Driving Box Equalizer, Side Rod Bushing and Many Others)

Fig. 18—Axle Brackets Are Multiple Machine Flame Cut from Slab by Nesting, and Then the Slot and Hole Are Cut in One Operation as Illustrated. (This Eliminates the Time-Consuming Machining Operations of Boring and Milling)

without drag lines. The precision obtainable depends upon:

1. The cutting equipment and procedure employed.
2. The cuttability of the material.

Other mechanical effects of oxyacetylene cutting result from warping due to the expansion and contraction of the steel in heating and cooling. When a part is locally heated, as in oxyacetylene cutting, it may warp, unless:

1. Its stiffness or cross-sectional strength is sufficient to resist the forces set up.
2. It is held in place by clamps or weights while cutting and cooling.
3. It is multiple cut, simultaneously or in rapid succession about its neutral axis, thus equalizing the forces set up and neutralizing their effect.
4. The cutting operation is immediately and progressively followed by rapid cooling or quenching with a suitable medium.

Plates of $^1/_2$-in. thickness and above are seldom warped or buckled by oxyacetylene cutting, unless unusually long or narrow. In such simple operations as cutting of rods, bars, rails, piping, structural shapes and similar lengthy materials, warpage is not involved. So-called "ship-cutting" is frequently used in splitting narrow materials such as flat bar stock and structural I-beams and channels to prevent warpage. In this method, the cut is made to skip at intervals, depending upon the work, leaving a series of uncut sections along the line of cut, each about $^1/_2$ to 1 in. long. These uncut ligaments hold the material in line until cooled, whereupon they are cut through to separate the parts. Sometimes simultaneous cuts, produced by two or more torches moved together along parallel lines, are made to eliminate warpage, increase production and reduce costs. For some operations, such as beam splitting, water quenching is an effective check to warpage. Where great accuracy is demanded in over-all dimensions of larger cut parts, suitable correction factors must be applied in making the cutting layout, particularly where the steel is preheated.

## MACHINE-CUTTING APPLICATIONS

### *Straight-Line Cutting*

Oxyacetylene straight-line cutting in the sizing of steel plates has constituted for a number of years an important application of the oxyacetylene process. It has enabled the steel mills to size cold steel plates and slabs in thicknesses greater than can be sheared. In most mills the maximum thickness which can be sheared cold is $1^1/_2$ to 2 in. It has also been employed to size plates of lesser thickness to closer specified tolerances than can be accomplished by shearing.

In fabricating shops, straight-line cutting has been employed to size plates more accurately than they can be furnished as sheared from the mill, either as a finished sizing operation or as a preliminary operation to final planing of the plate for welding edge preparation.

A straight-line cutting machine is essentially a motivated cutting blowpipe, and the smoothness of the resulting cut surfaces depends to a large extent on the operation of the propelling device. Looseness in traction wheels or play in driving gear trains will produce wobbly or intermittent blowpipe travel resulting in cuts of poor quality. Steel plates varying in thickness from $^1/_4$ in. to 24 in. are being cut daily. Any commercial machine must be capable of cutting plates of this range. Because of the need for using a different linear speed for each plate thickness, the driving motor must be controlled so that the blowpipe speed can be varied over a speed range which in most cases is from 2 to 30 in. per min.

To produce straight-line cuts, the machine must be properly guided. A rail or track is used by the cutting operator in much the same way that a straight edge is used by the draftsman; the cutting operator must, therefore, exercise considerable care in maintaining and aligning these tracks.

In the past it has been customary to place the machine track on the plate to be cut, lining it up to the plate layout. Recently the use of permanently installed track systems similar to machine-tool ways has become popular, particularly where a number of similar, large-size plates must be cut. If the track is to be supported on the plate, the track sections and the cutting unit must be light in weight in order that they may be easily transported and set up by the operator. On the other hand, if the track system is a permanently installed affair, the weight of the machine need not be kept at a minimum, but may be made purposely heavy in order to insure ruggedness and stability of operation.

### *Bevel Cutting*

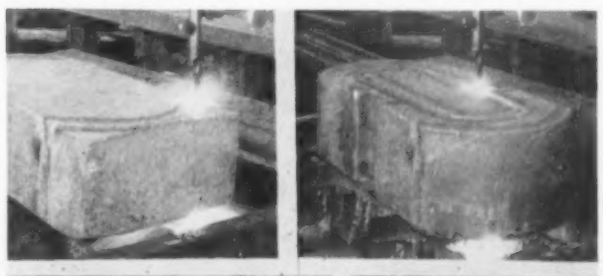
In straight-line cutting the cutting jet is projected perpendicularly to the plate surface, as shown in Fig. 4, and infrequent adjustments only are required to space the nozzle with respect to the plate. In bevel cutting, the cutting jet is projected at an angle to the plate surface, as shown in Fig. 5, and even slight variations in levelness will cause the edge to become scalloped. A plate-riding device employed to maintain a constant relation between nozzle and plate is, therefore, a necessary adjunct to the cutting machine used for bevel cutting. Preparation of a pressure vessel edge for welding is shown in Fig. 6.

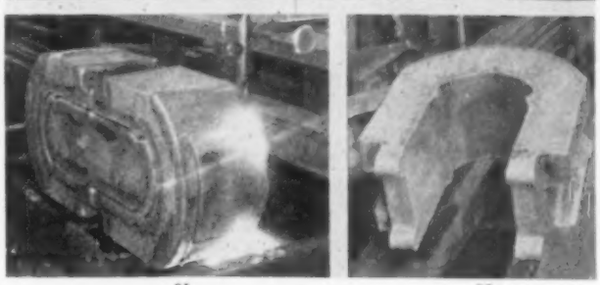
Welding fabricators have found that better fit-ups in assembly are obtained if a land or nose is placed at the bottom of the edge bevel. Edge preparations must, therefore, be made in two and sometimes three planes, requiring that either two or three separate passes be made on each edge, or that two or three cuts be made simultaneously, as shown in Figs. 7 to 9, inclusive. If the cuts are to be made simultaneously, a multiple of torches can

Fig. 19—Shaping Tops of Locomotive Driving Boxes from a 12$^1/_2$-In. Forged Billet

Fig. 20—Shaping the Inside Sections of the Two Driving Boxes

19 20





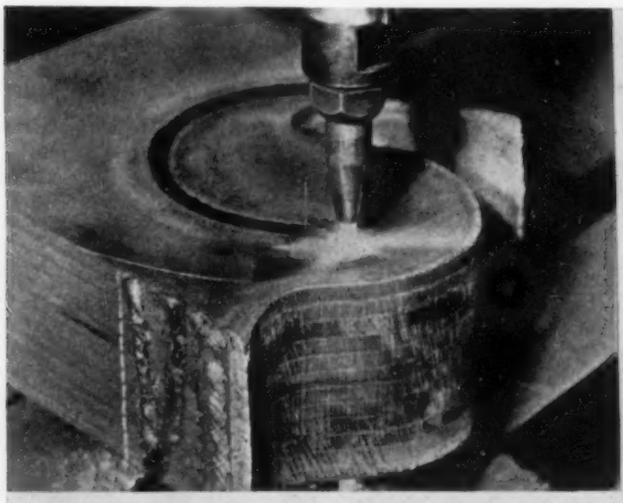
21 22

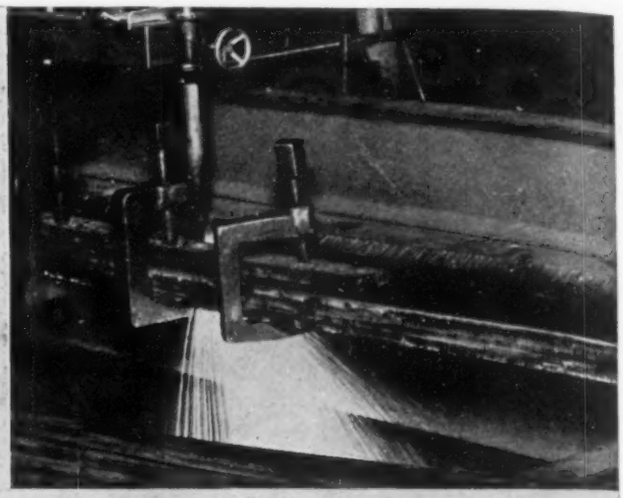
Fig. 21—Cutting Saddle Seat Recesses in Tops of Two Boxes

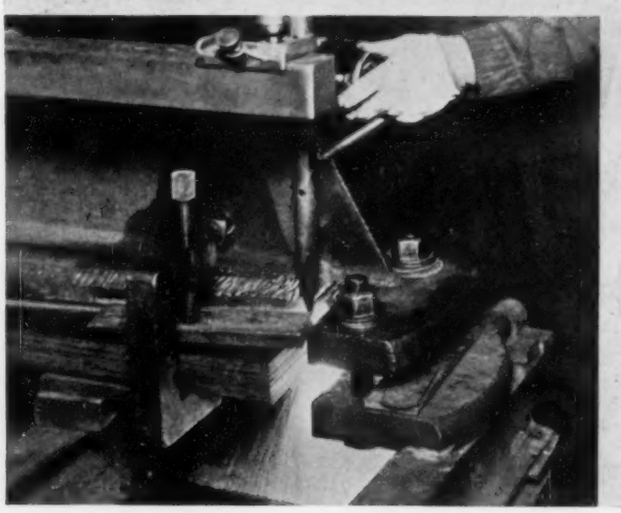
Fig. 22—One of the Completely Cut Boxes Ready for Machining

Fig. 23—Close-Up View of a Typical Plate Stack-Cutting Operation

Fig. 24—Stack-Cutting Has Its Place in Railroad Shops. (Fig. 24 Is Top Right) 35—3/32-In. Plates Are Being Cut Simultaneously to the Contour of Car Roof Carlines. The Clamp Consists of 2-In. Plates, Both Top and Bottom, Cut to the Carline Contour. An 8 In. I-Beam Is Welded to the Plate, to Keep It from Springing Out of Alignment. Bolting on Each End Completes the Clamping Arrangement. After Each Cut, the Bolts Are Loosened, and the Stack of Plates Advanced for the Next Cut. As Shown, the Cut Has Progressed About Half Its Length, from the Left. Note the Auxiliary Clamp, Which May Be Positioned Where Needed







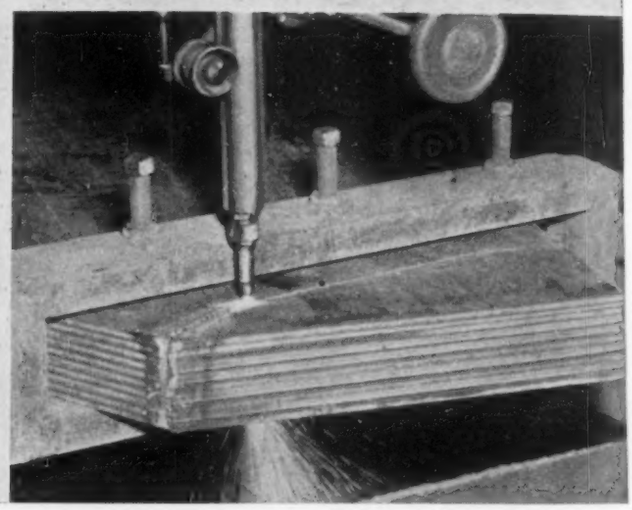


Fig. 25—Completion of Cut of Stack Shown in Fig. 24

Fig. 26—"Strong-Back" Clamp for Stacked Plate Cutting

be used, or adaptors for a single torch may be designed to hold two or three nozzles to suit the job at hand. The advantage in using multiple blowpipes, as shown in Figs. 10 and 11, is that they may be arranged to suit any combination of bevel angles for any combination of plate thicknesses.

The inexperienced operator finds it difficult at times to produce bevel cuts comparable in smoothness with straight cuts. If the cutting speed and oxygen quantity are regulated for the actual thickness being cut and not the nominal plate thickness, and if sufficient oxyacetylene preheat is used, no difficulty should be experienced. An example of high quality bevel cutting is shown in Fig. 12.

*Precision Machine Cutting*

Precision cutting is defined as the production of smooth cut surfaces with parallel kerf walls with no beading or burning of the top edges. The degree of cutting precision varies from shop to shop depending on the ability of the operators, the type and condition of the mechanical equipment, and the nozzles used.

Modern straight-line and shape-cutting machines are constructed for precise work. Accurately fitted guide wheels, the use of anti-friction bearings, and well-regulated driving units enable the operators to do work of high quality. The nozzles which meter and direct the cutting jets must be properly designed and accurately constructed if work of precise quality is to be produced.

With regular forward movement of the nozzle and with proper preheating, there may be obtained precision tolerances in plain carbon steel ranging from 0.003 in. for material 1 in. thick to 0.03 in. for material 6 in. thick. Such close tolerances are not, however, always commercially obtainable with ordinary nozzles. Figure 13 (*a*) shows how the kerf walls converge toward each other when 6-in-thick steel plate is cut in ordinary commercial practice. Figure 13 (*b*) illustrates the parallelism of the kerf walls when a precision type tip is used. Excellent examples of machine flame cutting to close tolerances are shown in Figs. 14 and 15.

*Shape Cutting*

A large part of the freedom in design which attends the fabrication industries today is due to the possibility of cutting work pieces of almost any size and shape from standard rolled steel plate, as shown in Fig. 16, with mechanically controlled and guided oxyacetylene cutting blowpipes. It has been proved time and again that small parts fabricated from flame-cut plates by welding are much more durable and rugged than castings. In the case of bulky parts, it has reached the point where the designer will prefer to use flame-cut items of the type illustrated in Fig. 17 instead of heavy castings because of the difficulty of securing sound castings where the metal thickness varies radically from section to section.

A very important contribution of machine flame cutting to the fabricators is the speed with which parts may be cut from steel plate as compared to any other means. Many items are simply drawn and then traced from the drawing with the shape-cutting machine. If the tolerances are close or if the item is desired in multiple, a template may be made and checked by cutting to produce the desired fit. Once a template is made and checked to produce a desired fit, it is known that all pieces cut from it can be relied upon to assemble within required limits. An example of multiple cutting of axle brackets is shown in Fig. 18.

Shape cutting is probably the most exact of the oxyacetylene processes. The well-trained operator must be able to read blueprints and be capable of making up his own templates therefrom. He must have a knowledge, which can be gained only from experience, of the manner in which work pieces react under the stresses produced by the localized heat of cutting.

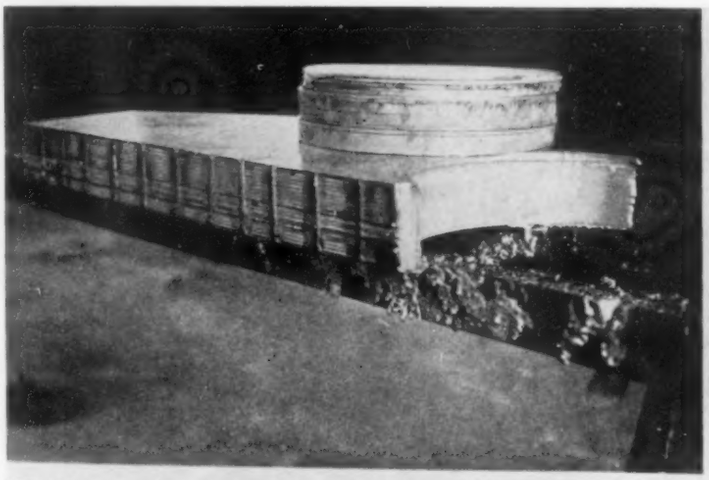
When steel pieces at room temperature are flame cut, the metal at the cut face is upset because it is restrained from expanding by the remaining colder metal. The cut face progressively cools as the cut advances, and contracts. Unbalanced forces are set up which tend to cause slight movements of the pieces. Usually the movement can be confined to the piece cut away from the desired pattern by offering no restraint to it. The desired pattern is usually restrained; in some cases, however, restraint from moving is produced only by the supporting structure.

The irregular shape-cut piece is usually somewhat distorted, and an allowance must be made for distortion when templates are made. The amount of distortion can be regulated to a large extent by selecting the proper sequence of cutting. Only experience can aid the operator in the selection of a proper sequence for a job at hand. If the work piece is thoroughly preheated before cutting, expansion and contraction, with the resulting localized stresses, are reduced or completely eliminated, depending on the temperature of the piece. Allowance must, however, be made for the inevitable cubical contraction which will occur when the finished item cools to room temperature.

The fabrication of two locomotive driving boxes from a $12^1/_2$ in. thick slab weighing 3900 lb. is illustrated in

Fig. 27—Welding Beads Used as Clamping Means to Make Possible Simultaneous Cutting of 20 Circular Pieces

Fig. 28—Completing Cutting of Hole in Back End of Locomotive Main Rod. (Before Cutting, the Rods Are Preheated to About 1000° F. The Starting Holes for the Internal Cuts Are Either Drilled or Pierced with an Oxygen Lance. "Lead-In" Cuts Are Used)



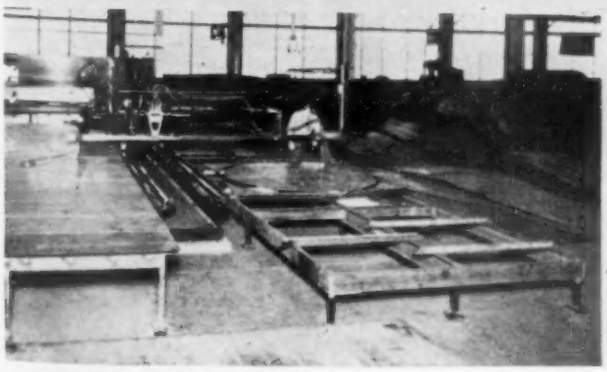


Fig. 29—Machine Flame Cut of a Circular Shape, 90 In. in Diameter, Nearing Completion. (Note the Arrangement for Holding the Radius Rod Center in Position While the Cut Progresses. The Operator Is Watching the Torch, Since Circle Cutting, After Starting, Is Practically Automatic, When the Manual Tracer Is Equipped with a Radius Rod)

Fig. 30—Large Diameter Circle Cutting Using a Portable Type Cutting Machine with Long Radius Rod

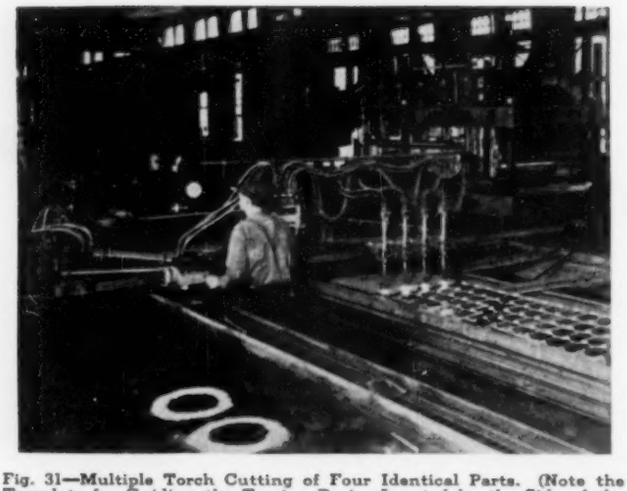


Fig. 31—Multiple Torch Cutting of Four Identical Parts. (Note the Template for Guiding the Tracing Device Located by the Side of the Operator. Considerable Economies in Labor Cost Are Realized by This Method)

the following figures. Figure 19 shows the shaping of the arcular top of the boxes. Figure 20 shows the shaping of the inside sections and Fig. 21 shows the shaping of the box bottoms. In Fig. 22 the completed box is shown, ready for machining. The weight of each box is now 816 lb. or a total of 1632 lb. for both. A total of 24½ ft. of cutting was performed. All of the cutting was guided from templates which were mounted on the same backing in a compact arrangement.

*Stack Cutting*

When thin steel sheets are cut separately, operating difficulties arise due to the tendency of sheets of ⅜-in. thickness and under to warp when subjected to the heat from the cutting flame, and because of the tendency of the slag produced in cutting to bridge the cutting slot, sticking hard to the severed edges. The economy of such an operation is low because of the progressively increased rate of oxygen consumption for cutting sheets when the thickness falls below one inch, and because of the relatively low production rate, expressed in lb. of steel fabricated per hour. A typical stack-cutting operation is shown in Fig. 23.

Stack cutting of thin steel sheets is one of the most practical and economical applications of the oxyacetylene process. Stacks of plates, ranging in individual thickness from 26 ga. to ½ in., may be sized or shape cut in numbers great enough to give an equivalent thickness of up to 6 in., provided a correct procedure is determined and followed. In Figs. 24 and 25 are shown the stack cutting of twenty-five $^{3}/_{32}$-in. plates to the contour of car roof carlines. Recommended procedures based on good past practices are available, but for each individual application it will be found that a new shop practice will be evolved which is best adapted to the production of the specific item. The recommended practices embody rules for preparing the plates, holding them during cutting, starting the cut and separating them after cutting. As far as the actual cutting is concerned, the operating technique is almost the same as for solid material. The preheat flame lengths and the oxygen pressures and quantities remain the same, but slightly lower cutting speeds are usually recommended.

For any stack-cutting application, the number of plates and resulting thickness to be cut will be determined by the existing shop program and auxiliary equipment. Some of the factors which determine the stack thickness are:

1. The size of plates and handling facilities.
2. The cleanliness of the plate.
3. The squareness and smoothness of the existing edges on the plates.
4. The tolerances required on the finished plates.
5. The cost of labor, acetylene and oxygen.
6. The facilities for holding the plates together.

It is usually found that the last factor—the clamping facilities— is the principal one.

Sheets to be stacked for cutting must be clean and flat, for it has been found that the maximum allowable space between layers is approximately 0.003 in. Therefore, all dirt, mill scale, rust and paint must be removed. Depending upon the condition in which the sheets are purchased and delivered, satisfactory cleaning methods may consist of pickling, sandblasting, wire brushing, flame descaling or a compressed air blast. In some cases the sheets are delivered in stacks arranged at the mill or warehouse, and require no preparation other than a dusting off with the compressed air blast.

Holding the sheets together during cutting to maintain the maximum of 0.003 in. between layers is probably the most important step in the process. Ingenious operators originate holding methods to suit the particular job. Probably the most common method is an arrangement of ordinary C-clamps. The C-clamp is a cheap, efficient and extremely versatile clamping device, but the pressure area is so small that in order to apply pressure over an appreciable area, it is necessary to use several clamps and to make use of pressure bars, rings or plates to distribute the force along the line of cut.

An adaptation of the C-clamp is the deep-throated "C" or horizontal "U" frame which "forks" the stacked plates. Wedges are then driven between the stack surfaces and the frame jaws to exert the necessary pressure. The frames may be flame cut from steel plate and provided with any desired throat depth. Such frame-type clamps can be positioned in any desirable manner. A "strong-back" type clamp is shown in Fig. 26.

If the plate stack is to be cut close to an edge where it

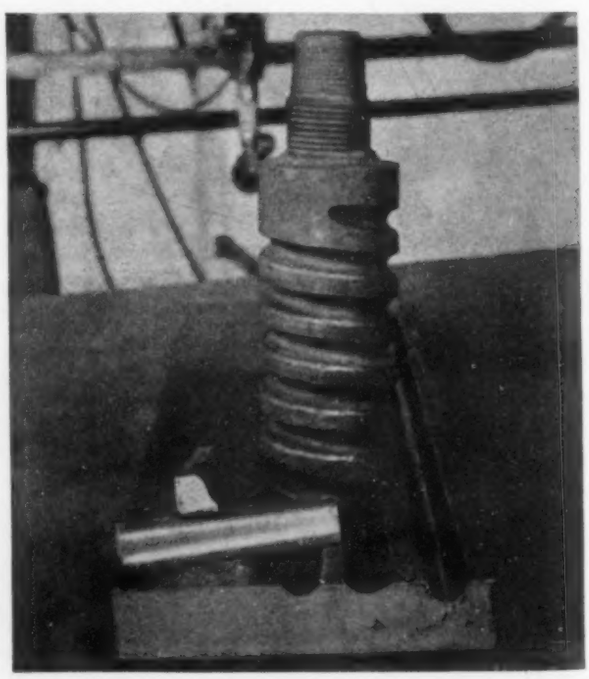


Fig. 32—Assortment of Flame-Machined Parts. (Showing a Coarse Pitch Screw, a Plate with Single and Double-Gouged Grooves, and Samples of "J" Grooves for Welding)

might not be feasible to use clamps, the plates can be held together with welding beads applied across all the edges, as shown in Fig. 27. The proper spacing of the welding beads should be determined by practice.

In some shops where considerable quantities of repetitive items are produced, and the operators have become used to the process, permanent "set-ups" for stack cutting have been installed. Compressed air and hydraulic jacks appear to be favored for clamping arrangements in these installations.

Next to adequate clamping, a correct procedure for starting the cut is most important. A false start may damage the stacked plate edges sufficiently to warrant their discard. Probably one of the most common procedures is to line the edges up straight from top to bottom and then preheat along the face of the projected cut with a welding torch. With a kerf face raised to the ignition temperature, easy starts are made.

A very satisfactory procedure is to align the plates so that each projects slightly over the one below at the starting edge of the stack. Then as the blowpipe advances, the cut begins in the top plate and gradually progresses down through the remainder. The same progressive starting effect may be accomplished on squarely aligned plates by swinging the torch at starting through an angle of approximately 15 deg. into the perpendicular running position.

If interior cuts are being made on rings or other shapes, cutting starts cannot be made at outside edges. It is then customary to use a hole drilled through the stack as the starting point. When using a drilled hole, care must be exercised to remove the burrs from the hole edges and to arrange the plates so that the successive holes are in perfect alignment.

When small shapes are cut from light plates, a thicker "waster" plate is frequently placed on top of the stack to assist clamping, and to prevent overheating of the upper sheets in the stack. The "waster" plate is cut through with the remainder and is subsequently discarded, but it takes the heat abuse resulting when the line of cut doubles back on itself, which frequently happens in shape cutting.

The cutting operation produces a smooth, continuous cut surface on the plate stack as illustrated in Fig. 27. The continuous surface appears to be the result of a light fusion at the surface contacts. The depth of fusion, determined by microscopic examination, is only approximately 0.005 in., and if the individual plate thickness is 10 ga. or over, the sheets separate easily by dropping the stack from a 3-ft. elevation. If, however, the thickness is less than 10 ga., some difficulty may be experienced. The most feasible means of separation at the present time appears to be a grinding operation. It has been found that if approximately one-third the cut surface of the fused stack is ground to a depth of 0.005 in. with a portable grinder, the sheets then start to separate of their own accord.

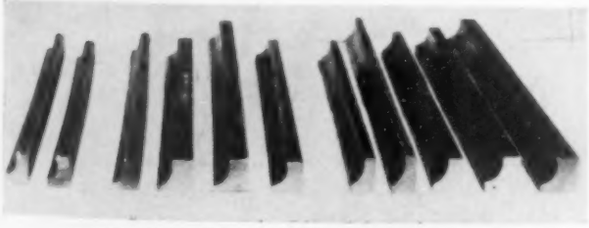


Fig. 33—Typical Half "U" and "J" Grooves

Fig. 34—Flame Turned 8-In. Diameter Round Bar

*Circular Cutting*

The first departure of oxyacetylene cutting from the straight line was probably in the cutting of circles. The operator who first attached a radius bar to a hand-cutting blowpipe probably adapted the idea from the use of the draftsman's compass. Unlike the compass, however, an oxygen jet of appreciable width is the tracing medium instead of a pencil point, and a slot of a width varying according to the work piece thickness and the nozzle size is produced in the work piece. In circle cutting, therefore, the operator must make due allowance for the slot width.

Circle cutting may be divided into two divisions: First, hole cutting, as shown in Fig. 28; and second, disk cutting, as shown in Fig. 29, depending upon which piece is the desired one. Circle cutting may be performed by using a radius rod fastened to the blowpipe and geometrically centered, or it may be accomplished by driving from a template tracing mechanism attached to a pantagraph blowpipe support.

In general, circle cutting falls within the category of precision cutting. Because of the circumferential trajectory of the nozzle, lag is not allowable; otherwise the cut surface would not be square with the plate surface. If proper precautions are taken during cutting, subsequent machining is rarely required. The kerf or cutting slot should be maintained at a uniform width; otherwise the circle will be out of round. Precision nozzles of the multi-flame type are recommended, for with this type the width of kerf is uniform regardless of changes in direction of the nozzle advance.

Great dimensional accuracy may be obtained by the oxyacetylene process in the cutting of circles. Because of the symmetry of the resulting work pieces, the cooling stresses are of radial and tangential nature and are, therefore, practically negligible. Movement of the work piece during cutting may be minimized or entirely prevented.

If the desired piece is a disk, and a radius rod is used to guide the cutting tip at a fixed distance from the center, as shown in Fig. 30, the line of cut will be on the true circumference. If, however, a template is used to guide the driving mechanism, the work piece may move with respect to the line on which the nozzle progresses, and

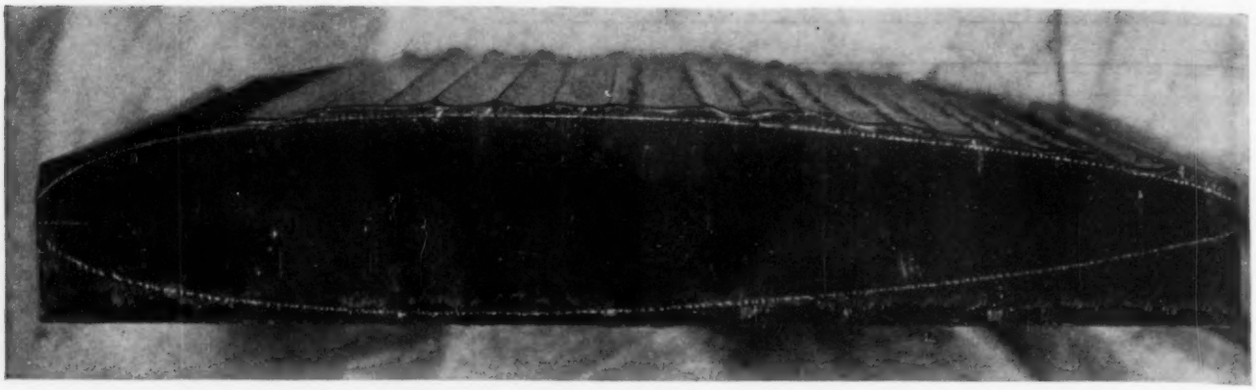


Fig. 35—Flame-Shaped Perpendicular Shaft House Strut

the resulting disk may be cut out of round. Under these circumstances the work piece must be clamped to immovable supports. Special clamps have been devised to hold disks allowing the excess metal or scrap piece to move at will. If such clamps are not available, a well-known expedient is to clamp down the piece out of which the disk is to be cut, and then as the cut progresses, to drop spacer pieces into the kerf to prevent the disk from moving.

If the desired piece is one with a hole it should, of course, be clamped to an immovable supporting structure. With a radius rod in use, the center may move with the disk as the cut nears completion unless the disk is securely fixed. Here, again, special clamps may be used to restrain the disk, or spacer pieces may be introduced into the cutting kerf.

*Multiple Torch Cutting*

Duplicate cuts may be simultaneously performed by a single cutting machine, as shown in Fig. 31, if provisions are made for mounting additional blowpipes on the supporting carriage. In the production of small items for welded fabrication, as many as six pieces are cut simultaneously. Concentric circles for flanges and the like often are cut in one operation using two torches. For cutting long narrow plates, it has been found that not only is the time required for cutting reduced by making the two cuts simultaneously, but the strips which would otherwise be badly warped are practically straight.

## FLAME MACHINING

Since the introduction of oxyacetylene cutting, efforts have been made to apply the process as a substitute for tool machining in applications where considerable amounts of metal must be removed. Tool-machining jobs of this kind would be classified as planing, turning, shaping, boring, pneumatic chiseling and back sawing. For work of this nature an oxyacetylene cutting nozzle is substituted for the tool bit. Oxyacetylene process applications comparable with the above machining operations are U-groove plate-edge preparation, flame turning, flame shaping, flame billet centering, flame gouging and flame billet cutting. A collection of flame-machined parts is shown in Fig. 32.

*U-Groove Plate-Edge Preparation*

For arc welding steel plates greater than $^1/_2$ in. in thickness, the half "U" or "J" type of edge preparation, as shown in Fig. 33, is the most economical. When such plates are butted together, a "U" is formed to receive the filler metal. Because of the clearance in the trough, no difficulty is experienced in inserting the electrode and in making a sound, penetrating weld on the first pass. As the trough is filled, the width of each succeeding layer is increased only enough to prevent undercutting. The almost uniform width of the deposited metal throughout its depth is a factor which tends to reduce distortion.

The flexibility and low cost of oxyacetylene equipment enable even the small fabricating shop to obtain the advantages inherent in this form of plate-edge preparation. Flame-machined U-grooves may be made with an ordinary deseaming nozzle. Better quality work can be obtained with a more suitable nozzle such as the one designed for gouging. The nozzle may be mechanically driven to produce long, uniform cuts.

*Turning*

Round billets of steel equivalent to S. A. E.-1020 have been turned in lathes on which the tools have been replaced by oxyacetylene cutting tips. It has been found possible to remove from $3^1/_2$ to 11 lb. of metal per nozzle per minute at an oxygen consumption rate of $3^1/_4$ to 6 cu. ft. per lb., depending upon the quality of work required. In grooves made at the higher metal removal rate and the lowest oxygen consumption, a considerable amount of slag cleaning must be done. Figure 34 illustrates work of the best quality, the turning being performed at the lower metal-removal rate and the higher oxygen consumption. It is to be noted that little, if any, slag cleaning must be done. The above metal-removal rates compare favorably with a maximum for machine-tool turning per tool bit.

*Shaping*

Similar work has been done to determine metal-removal rates for shaping operations, and it has been found possible to remove from 7 to 9 lb. of metal per nozzle per minute at an oxygen consumption rate of $2^1/_2$ to 4

36 37

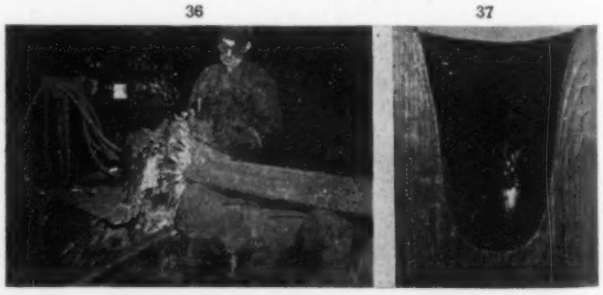


Fig. 36—Billet Centering Machine in Action

Fig. 37—Typical Flame-Bored Centers as Employed in Pierced Seamless Billets

cu. ft. per lb. The higher metal-removal rate and the lower consumption are obtained in some desurfacing operations. The lower metal-removal rate and the higher consumption refer to shaping operations such as for the Marine propeller shaft housing strut illustrated in Fig. 35. The maximum metal-removal rate per bit for machine-tool shaping is approximately $5^1/_2$ lb. per minute.

*Billet Centering*

The oxyacetylene cutting nozzle has replaced the boring machine for making centers on large forging billets which are to be machined and on seamless tubing blanks which are to be pierced. In a number of cases satisfactory work is accomplished manually with a deseaming blowpipe.

Where uniformity is desired such as in the preparation of seamless tubing blanks for piercing, stationary equipment such as that illustrated on Fig. 36 is used for machining both hot and cold material. This equipment is furnished with automatic timing devices so that the quantity of oxygen consumed and the resulting center contour are accurately controlled.

Billets from 2 to 8 in. in diameter can be given any of the center contours illustrated in Fig. 37, providing the proper nozzle and time of exposure are selected. On cold material, 9 to 15 seconds and from $^1/_2$ to $3^1/_2$ cu. ft. of oxygen are required for these centers. On material which is at a temperature of from 1800 to 2000° F., only 2 to 3 seconds and from $^1/_{10}$ to $^3/_4$ cu. ft. of oxygen are required to do the same job.

## SUMMARY

In the foregoing paper an attempt has been made to cover the more important aspects of the machine flame-cutting processes. Obviously, in a general survey of this sort space does not permit much detailed information.

The important phases of cutting technique have been referred to with some specific information, and the general features of the flame-cutting procedure on steels of various compositions have been indicated.

The principal purpose of the paper has been to set forth by illustration the numerous commercial applications of the machine flame-cutting and flame-machining processes, with the hope that the industrial uses cited may suggest other time- and money-saving jobs for this most flexible industrial tool.

# The Smit-Unionmelt Welding Process

THE smothered arc-welding process known as Smit-Unionmelt appears to be nearly identical with that described by Wallace[1] and Whittemore[2] in earlier issues of THE WELDING JOURNAL. The steel electrode is submerged during welding in liquid flux that conducts electricity. There is no difficulty in securing weld metal that will pass severe specifications for tensile strength, bend ductility, and notch impact value.

The conditions for making butt and fillet welds by the Smit-Unionmelt process are shown in Tables 1 to 4. It is pointed out that although welding currents are high, energy consumption per unit length of weld is low.

Footnote: Abstract of "Het Smit-Unionmelt Laschprocédé," published in *Smit Mededeelingen*, **1**, No. 1, 1940, pp. 17–40. Abstracted by G. E. Claussen.
[1] Wallace, R. M., AMERICAN WELDING SOCIETY JOURNAL, **18**, 17–26 (1939).
[2] Whittemore, C. R., AMERICAN WELDING SOCIETY JOURNAL, **18**, 156–163 (1939).

**Table 1—Unscarfed Butt Welds**

| Plate Thickness, In. | Spacing, In. | Diameter of Electrode, In. | Consumption of Electrode, Lb. per Ft. of Weld | Consumption of Flux, Lb. per Ft. of Weld | Current, Amp. | Welding Voltage, Volts | Welding Speed, Ft./Hr. |
|---|---|---|---|---|---|---|---|
| 0.20 | 0 | $^5/_{16}$ | 0.097 | 0.135 | 500 | 30 | 130 |
| 0.24 | 0 | $^5/_{16}$ | 0.14 | 0.175 | 600 | 32 | 98 |
| 0.32 | 0.08–0.12 | $^5/_{16}$ | 0.12 | 0.105 | 670 | 28 | 95 |
| 0.39 | 0.16 | $^1/_4$ | 0.17 | 0.160 | 1000 | 39 | 80 |

**Table 2—V Butt Welds**

| Plate Thickness, In. | Angle of V Degrees | Shoulder, In. | Diameter of Electrode, In. | Consumption of Electrode, Lb. per Ft. of Weld | Consumption of Flux, Lb. per Ft. of Weld | Current, Amp. | Welding Voltage, Volts | Welding Speed, Ft./Hr. |
|---|---|---|---|---|---|---|---|---|
| 0.24 | 60 | 0.12 | $^5/_{16}$ | 0.049 | 0.06–0.07 | 300 | 23 | 125 |
| 0.39 | 60 | 0.12 | $^1/_4$ | 0.25 | 0.23 | 825 | 30 | 100 |
| 0.47 | 60 | 0.16 | $^1/_4$ | 0.32 | 0.27 | 1100 | 36 | 100 |
| 0.59 | 45 | 0.16 | $^1/_4$ | 0.44 | 0.35 | 1170 | 36 | 75 |
| 0.71 | 45 | 0.16 | .. | 0.48 | 0.38 | 1175 | 36 | 57 |
| 0.98 | 35 | 0.12 | $^5/_{16}$ | 0.64 | 0.51 | 1400 | 32 | 57 |

**Table 3—Double V Butt Welds Made with Electrodes 1/4 Inch Diameter**

| Plate Thickness, In. | Scarf Angle, Degrees | Shoulder, In. | Number of Layer | Consumption of Electrode, Lb. per Ft. of Weld | Consumption of Flux, Lb. per Ft. of Weld | Current, Amp. | Welding Voltage, Volts | Welding Speed* Ft./Hr. |
|---|---|---|---|---|---|---|---|---|
| 0.47 | 90 | 0.16 | first | 0.18 | 0.33 | 725 | 26 | 105 |
| 0.47 | 90 | 0.16 | second | 0.088 | 0.12 | 750 | 35 | 115 |
| 0.59 | 90 | 0.20 | first | 0.22 | 0.37 | 750 | 35 | 101 |
| 0.59 | 90 | 0.20 | second | 0.18 | 0.27 | 825 | 35 | 105 |
| 0.71 | 90 | 0.24 | first | 0.25 | 0.4 | 950 | 38 | 88 |
| 0.71 | 90 | 0.24 | second | 0.26 | 0.45 | 900 | 35 | 90 |
| 1.0 | 70 | 0.32 | first | 0.43 | 0.5 | 1025 | 35 | 91 |
| 1.0 | 70 | 0.32 | second | 0.19 | 0.26 | 750 | 35 | 96 |
| 1.6 | 45 | 0.39 | first | 0.44 | 0.4 | 1100 | 35 | 70 |
| 1.6 | 45 | 0.39 | second | 0.51 | 0.4 | 1050 | 35 | 70 |

* Welding speed is the rate of travel of the electrode in welding each side only.

**Table 4—Horizontal Fillet Welds**

| Plate Thickness, In. | Diameter of Electrode, In. | Consumption of Electrode Lb. per Ft. of Weld | Consumption of Flux Powder, Lb. per Ft. of Weld | Current, Amp. | Welding Voltage, Volts | Welding Speed, Ft./Hr. |
|---|---|---|---|---|---|---|
| 0.20 | 3/16 | 0.19 | 0.135 | 600 | 30 | 108 |
| 0.28 | 3/16 | 0.22 | 0.15 | 650 | 30 | 88 |
| 0.39 | 5/16 | 0.35 | 0.22 | 950 | 30 | 75 |

# Flame-Cutting Clad Steel

By H. F. LASSNER*

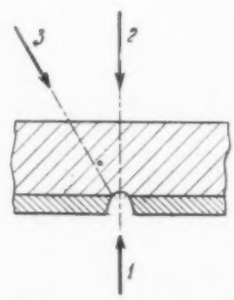
THE steadily increasing use of clad steel plate in the construction of pressure vessels and processing equipment for the chemical industry is primarily due to the considerably lower costs of a corrosion resistant veneer of Nickel, Inconel, etc., as compared with solid plate of said material. Furthermore, in welding clad plate, the consumption of expensive alloy electrodes corresponds only to the thickness of the cladding, which amounts generally to 10 to 20% of the plates total thickness.

In welding clad plate the generally applied method is to weld the plain steel side first, then to clean the opposite alloy side carefully by chipping, grinding, brushing, and then to weld the veneer.

Less standardized than this welding method is the way of preparing the edges before welding. Today, in fabricating carbon-steel plate, beveling of the edges by oxygen-cutting is the common practice because of its high economy and speed. As Nickel and stainless steel cannot be flame-cut, in many shops the opinion is still prevalent, that Nickel and stainless-clad plate are equally impossible to sever.

As a matter of fact, an attempt to cut Nickel-clad plate as if the cladding did not exist, would fail, even if the cutting torch would be applied to the steel side. The flame will burn through the steel plate, but will not sever the veneer. The heat will produce a broad crater in the steel portion exposing the inner Nickel surface of the cladding.

Suitable methods developed for successful flame-cutting clad material have been recently reported in this and other papers. To obtain a perfect cut, it is essential to preheat carefully the area from where to start on the clad side and to weave the torch in the direction of cutting during the cutting operation. The faces of the cuts are smooth and the cutting-speed is only slightly lower than with plain steel plate of the same thickness.




Operation 1—Chipping the Veneer
Operation 2—Cutting Off Plate
Operation 3—Beveling Plate

It is characteristic, that cutting becomes easier the thicker the plate is. The thermochemical reaction of the stream of liquid slag and molten iron (produced by the cutting of the steel portion of the plate) with the cladding material—a sort of alloying process—makes the cut possible. With greater thickness of the plate the quantity of cut-promoting slag increases, thus facilitating the cutting of the veneer.

The objection may be raised that this procedure may create carbides and change the cladding structurally in such a way that it loses its highly important quality of corrosion resistance. However, after cutting the edges must pass through another melting process, i.e., welding, thus creating another change in the structure of the cutting face. Even if the material should have lost its corrosion resistance quality to a certain extent after cutting, by subsequent welding with high-alloy electrodes it undergoes another melting and alloying process, which may restore its chemical resistance sufficiently for practical purposes.

* Consulting Engineer.

An investigation of the chemical and structural changes aroused by flame-cutting and subsequent welding of clad plate would be of interest and practical importance.

Trials have shown that Nickel- and Monel-clad steel appears easier to cut than Inconel- and stainless-clad steel. This seems to point to a fact, which is already known. Nickel-iron alloys, which are formed when flame-cutting Nickel-clad steel, may be severed even if they have a considerable Nickel content.† On the other hand, the kindling temperature of chromium-iron alloys, which exist or are formed when cutting stainless- and Inconel-clad plate is so high, that it cannot be reached with the usual flames within the time required for a continuous cut.

In the actual tank shop practice there are two main operations wherein flame-cutting clad plate may produce valuable advantages. One is the preparing of the shell plate edges for the longitudinal and circumferential joints and of the edges of the heads for the circumferential joints. The shell plates, as they are delivered from the mill, have not the exact width as required. Their edges may be not exactly straight, variations of one inch and more may occur. To obtain a straight edge, superfluous material has to be sheared off. Where shearing is not practicable, it has become customary to chip away the cladding along the line to be cut. The plate can then be flame-cut from the steel side along the same line. Then, as a second operation, the edge has to be beveled. This beveling is mostly done by means of a transportable flame-cutting machine. Only the steel part is beveled.

By flame-cutting through the veneer two operations, i.e., straightening the edges and beveling are reduced to one, a simplification saving time and labor.

The other operation in tank construction, where flame-cutting is important, is cutting the openings in the shell and head plates before attaching manhole-bodies, and outlets of any sort. Usually clad plates, like plain steel plates, are laid out on that side which after forming or rolling will be outside the vessel, thus facilitating the assembly and fitting-work. Chipping of the clad side along the contours of the openings necessitates additional layout of these contours at the cladding side. Whether this second layout is exactly congruent with the corresponding outside layout, is a matter of accuracy of the person laying out the work. However, in practice differences are very likely to occur. With such differences, even of a small order, the flame-cut from the outside may not coincide with the chipped groove inside. As operators are not yet trained in the proper practice of cutting clad plate through the veneer, every shopman will realize the difficulties arising from such cases.

An example will illustrate the advantage of flame-cutting clad plate. A removable flared and dished head of a kettle has 6 ft. O.D., the clad plate having $1^1/_2$ in. total thickness, the cladding being 20% of the total. This head is to have 10 different size circular openings as for the agitator drive stuffing-box, manhole, inlets and outlets, thermowell-connection, etc. In order to be chipped inside, these openings must be laid out inside. The additional labor costs cannot be neglected in a planned production of a series of such kettles. Of greater importance is the amount of labor which chipping itself requires. A good worker will need about 8 hours using modern pneumatic tools for chipping out the 10 contours. When flame-cutting through the cladding, the labor costs for both laying-out and chipping can be saved, the time of production can be shortened by one whole day and all inconveniences caused by differences between inside and outside layouts may be avoided.

In conclusion it should be mentioned that every skilled flame-cutter can learn the proper technique for flame-cutting clad plate within only a few hours spent on practicing on scraps before cutting work of some value.

† German literature mentions a limit of 34% Nickel for possible flame-cutting.

# CURRENT WELDING LITERATURE

Airplane Manufacture. Welding Technique in Aircraft Construction—III and IV, K. Queitsch. Aircraft Eng. (Mar. 1940), vol. 12, no. 133, pp. 87–89; (Apr.) no. 134, pp. 125–126.

Aluminum. Repair Welding, Brazing and Soldering of Light Metal Castings, E. R. Thews. Metal Industry (N. Y.), vol. 38, no. 2. (Feb. 1940), pp. 84–86; (Mar.), no. 3, pp. 149–153.

Automobile Engines. Crankshaft Hardening. Steel (Apr. 29, 1940), vol. 106, no. 18, pp. 50, 52 and 78.

Brazing Aluminum Alloys, A. H. McGraw. Product Eng. (Apr. 1940), vol. 11, no. 4, pp. 176–179.

Electric Welding as Integral Part of Structural Design, B. P. Haigh. Shipbldr. & Mar. Engine Bldr., vol. 47, no. 368 (Annual Int. No.), Apr. 1940, pp. 149–151.

Electric Welding Machines. Drooping-Characteristic Welding Generator. Engineering (Feb. 16, 1940), vol. 149, no. 3866, p. 181.

Electric Welding, Power Supply. Integrated Supply Improves Service to Welders, W. B. Hurley and W. Smith. Elec. World (Apr. 20, 1938), vol. 113, no. 16, pp. 44–46.

Electric Welding, Resistance. Resistance Welding—What, Why and How, L. D. Jennings. Iron Age (May 9, 1940), vol. 145, no. 19, pp. 38–43. Various types of resistance-welding methods

(*Continued on page 515*)

# WELDING METALLURGY

**By O. H. HENRY and G. E. CLAUSSEN**

A series of lectures prepared for presentation in a fundamental course of metallurgy and metallography at Polytechnic Institute of Brooklyn under the joint auspices of the Institute and the New York Section of the AMERICAN WELDING SOCIETY. To be published serially in The Welding Journal. Available in Pamphlet Form—47 pages, Journal Size. Copiously Illustrated. $1.00 per copy. Special Prices quantity lots ten or more.

# Part VIII—The Solid Weld

We have discussed the weld melt, which is within the operator's control, and it now remains to discuss what happens to the solidified weld metal and the remainder of the plate during cooling after welding. We wish to know what happens because the temperature rises above the melting point during welding and we know that heating to and cooling from a high temperature may make a radical change in the properties of the steel. In our discussion we shall imagine that we are watching a fusion weld being made, and that we have two instruments: (1) a microscope that reveals the grain structure of the steel at all points on the plates to be welded and at all times during welding, and (2) a thermometer which automatically records the temperature at all points on the plates to be welded and at all times from the beginning to the end of welding.

### The Single-Pass Pure Iron Weld

Suppose the weld is a single-pass butt weld between two unscarfed sheets of pure iron. We have arrived on the scene with our instruments after the operator has partly finished the weld. We put our automatic thermometer into action and obtain a picture such as that shown in Fig. 52. The weld melt (liquid iron) is mostly above the melting point but is at the melting point at its boundary. The advance boundary of the weld melt is melting the iron ahead, whereas the rear boundary is freezing. The automatic thermometer shows that the frozen iron in the weld cools as the operator moves the weld melt farther ahead. The frozen weld metal cools at a slower rate than the iron in advance of the weld melt is heated. The metal on both sides of the weld also is heated, the temperature rise being greatest at points close to the weld. Point $B$ was at room temperature when the operator started welding. When the weld melt came close to $B$, the temperature at $B$ rose quickly to a little over 1400° C., then fell as the weld melt passed on, until it is at about 800° C. at the moment we are making our observations.

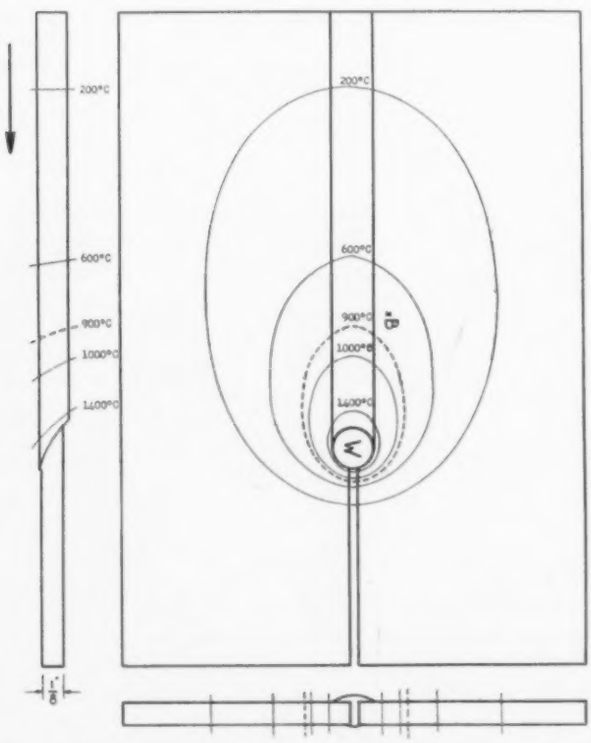



**Fig. 52—The Temperature in an Iron Plate at an Instant During Welding**

*W* = Liquid weld metal (weld melt) the boundary of which is at the melting point (1530° C.)

Within the dotted curve all is gamma iron. The iron outside the 900° C. curve is in the alpha crystalline form

Arrow indicates direction of welding

Note: All points on the curve labeled 200° C. are at 200° C., all points on the 600° C. curve are at 600° C., etc. All points between the 200° C. and 600° C. curves are at temperatures between 200° and 600° C. The curves are similar to the contour lines on topographic maps, and are called "isotherms"

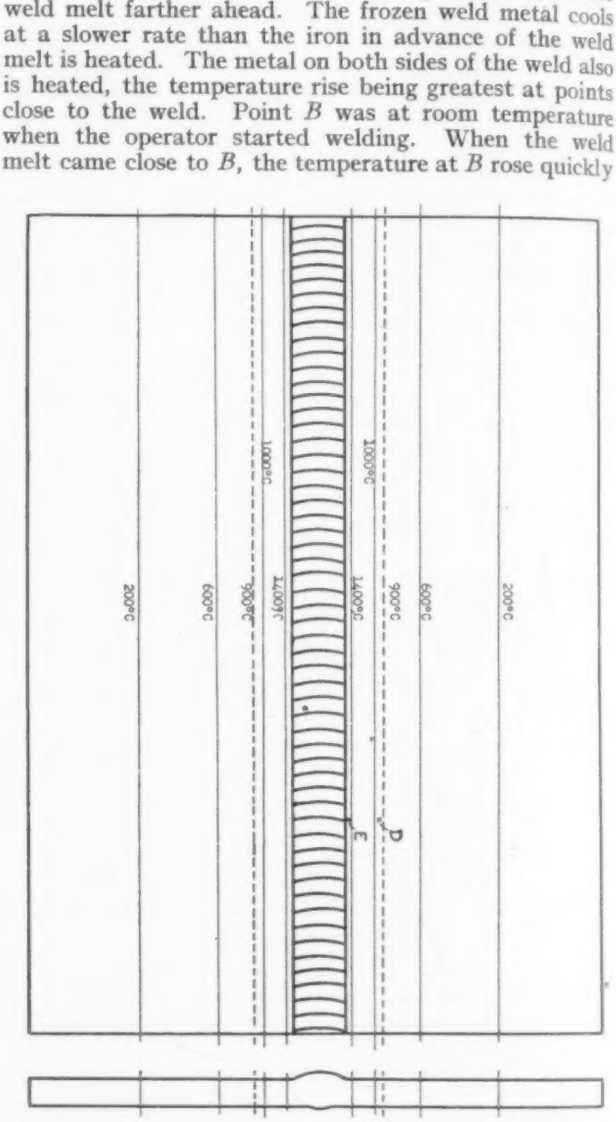



**Fig. 53—Distribution of Maximum Temperature in Welding an Iron Plate**

All points between the lines marked 200° C. have reached at least 200° C. during welding. All points outside the lines marked 200° C. have not reached 200° C. at any time during welding. Point *D* has reached a maximum temperature of between 900 and 1000° C. during welding, whereas point *E* has reached a maximum temperature of over 1400° C., but has not reached the melting point of iron

In a similar manner every other point on the plates rises to a maximum temperature and cools again to room temperature during the welding operation. The maximum temperatures attained are shown in Fig. 53. The exact location of the lines will depend on the welding process, the backing material, drafts and numerous other variables.

We are now ready to use our microscope. Reverting to Fig. 52, we observe that inside the dotted curve for 900° C. the iron grains are in the gamma form. (For

simplicity we neglect the 1400° C. transition.) Outside the curve for 900° C. the weld metal and plates are in the alpha, body-centered cubic form. In terms of maximum temperatures, Fig. 53, we know that every part of the plate between the weld and the 900° C. line has changed to the gamma form and back again to the alpha during welding. Outside the 900° C. line the iron grains have remained in the alpha form at all times during welding. It is easy to see that point *D* was heated only a little above 900° C. and remained in the gamma form only very briefly. Point *E*, on the contrary, was heated several hundred degrees above the transition temperature, and remained for a comparatively long time in the gamma condition.

Our microscope shows us that the grains of iron outside the 900° C. line remained unchanged throughout the welding operation. However, if the plates had been cold rolled before welding, the grains would have been distorted. In that event, the grains at all points that reached a temperature above 500 or 600° C. would have recrystallized and would have been softened.

Within the 900° C. line we find by means of our microscope that every alpha grain, as soon as it reached 900° C. changed to several gamma grains. Upon being heated above 900° C., the gamma grains grow, particularly at temperatures above about 1100° C. Needless to say, grains that have grown during a rise in temperature do not break up into smaller grains on cooling unless work is applied (forging) or unless the grains undergo a transition. During subsequent cooling through 900° C., each gamma grain transforms to numerous grains of alpha iron. The larger the gamma grains at 900° C., the larger will be the alpha grains resulting from the transformation.

After the welded joint has cooled to room temperature we find that the weld metal consists of coarse grains of alpha iron arranged in a way that we recognize has arisen from gamma iron that has not been hot worked. On either side of the weld, Fig. 54, there is a zone of coarse alpha grains that have been formed from coarse gamma grains heated above about 1400° C. but not melted during welding. Farther from the weld the grains become smaller until a zone of extremely fine alpha grains is observed at a position corresponding to the 900° C. line. Still farther from the weld is found the original structure of the iron before welding, unless the iron was cold worked before welding. In that event, the fine-grained zone will be followed by a zone of recrystallized grains, beyond which will be the harder distorted grain typical of cold worked iron, Fig. 54 (bottom).

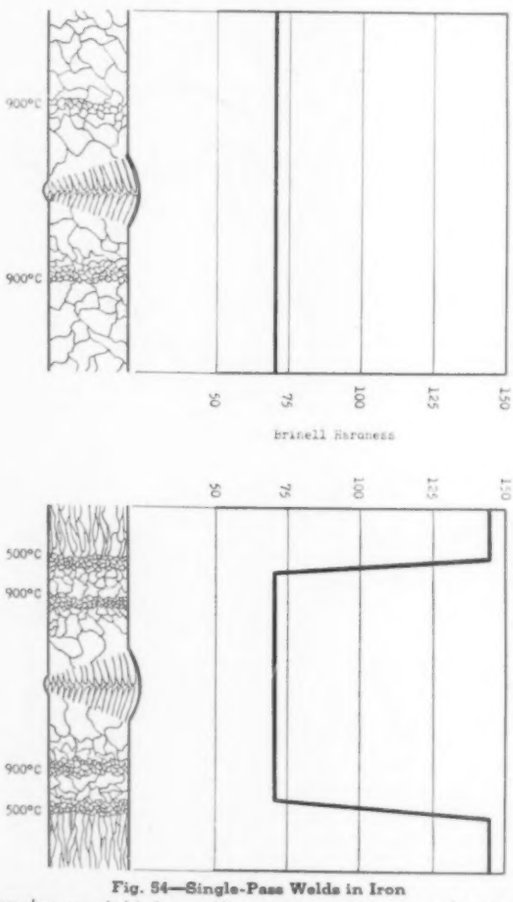



**Fig. 54—Single-Pass Welds in Iron**

Upper—Iron annealed before welding. Note grain refinement in the vicinity of the zone that has reached about 900° C. during welding. Chart at right shows that welding did not affect hardness.

Lower—Iron cold worked (cold rolled) before welding. Note grain refinement in the vicinity of the zones that reached 500° C. (approximate temperature of recrystallization) and 900° C. Chart at right shows that welding softened the iron in the zones that were heated above 500° C.

### The Two-Pass, Pure Iron Weld

The single-pass weld in pure iron consists of coarse grains in the weld metal and in the base metal adjacent to the weld. The grains will be much coarser in a large, single-pass weld made at slow speed that in a thin single bead deposited at a high speed. Nevertheless, coarse grains are undesirable for they lack the ductility of small, fine grains. To convert a coarse grain of alpha iron to a number of fine grains, simply heat it through 900° C. In this way a number of fine gamma grains are formed. If the iron is not heated far above 900° C. before cooling, each fine gamma grain will transform at 900° C. to a number of alpha grains. A double refinement will have been effected.

The double refinement of grain size may be accomplished by depositing a second bead over the first bead. As the temperature of the first bead is raised through 900° C. by the advancing second bead, each coarse alpha grain in the first bead changes to numerous fine gamma grains. These grow under the influence of the adjacent weld melt. During cooling, the gamma grains in the first bead transform at 900° C. to still finer alpha grains, which are finer than the corresponding alpha grains of the second bead for the reason that the gamma grains growing from the weld melt are far larger than the gamma grains that sprouted from the alpha grains of the first bead, as our microscope demonstrates.

A two-pass weld in pure iron thus consists of a fine-grained lower bead and a coarse-grained upper bead. The average size of the grains will be much smaller in the two-pass weld than in a single-pass weld of the same size. Consequently, the two-pass weld will have superior ductility. If the weld is made in more than two passes, the proportion of fine-grained material increases.

### The Single-Pass Weld in Steel

We have seen from our study of the distribution of temperature in fusion welding in pure iron plates that all parts of a cold worked plate that rise above about 500° C. recrystallize and become soft, and that all parts that rise above 900° C. during welding transform to gamma iron. There is a coarse-grained region adjacent to the weld and a fine-grained region farther away. We now extend the discussion to steel, and we select a steel containing 0.20% C, which is the carbon content of a large proportion of the steel that is welded. As with pure iron, we will watch an

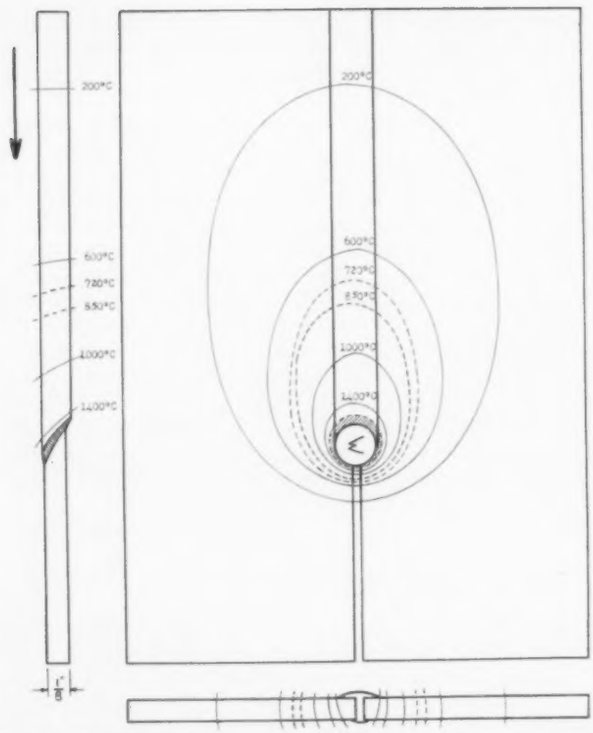



**Fig. 55—The Temperatures in a Mild Steel Plate at an Instant During Welding**

*W* = liquid weld metal (weld melt); the shaded area is the metal that is in the mushy stage, the boundaries of which are the liquidus and solidus temperatures: 1490 and 1520° C.

Between the shaded area and the curve labeled 850° C. all is austenite (gamma). The steel between the curves labeled 850° C. and 720° C. is a mixture of ferrite and austenite

Arrow indicates direction of welding

operator making an unscarfed butt weld in sheets $^1/_8$ inch thick in a single pass.

Bringing our automatic thermometer into play when the operator is about midway across the sheets, we observe the temperatures shown in Fig. 55. According to expectations, the temperatures are almost identical with those observed with pure iron, for 0.20% C has a negligible effect on the conduction of heat and welding characteristics of iron. When we look through our microscope, however, we find that there are differences in the grain structure compared with the weld in pure iron. The differences are observed in two regions:

1. The steel immediately surrounding the weld melt is in a mushy condition, signifying a mixture of crystals and liquid.
2. Inside the 850° C. curve the steel is in the gamma form, while between the 850° C. and 720° C. curves the steel consists of a mixture of alpha (ferrite) and gamma (austenite) crystals.

Apart from these differences the conditions are identical with those in the pure iron weld. The austenite crystals in the solid weld are coarse and transform on cooling to coarse ferrite crystals. In passing, it may be mentioned that it is never correct to refer to the structure of the weld as a "cast" structure. A casting solidifies from the mold walls inward, a process providing ample opportunity for shrinkage cavities, blow-holes and cracks. The weld, on the contrary, solidifies progressively along an advancing surface.

The differences in structure between the welds in pure iron and in steel become obvious if we are familiar, as we now should be, with the equilibrium diagram for steels (iron-iron carbide alloys). For convenience, the "thermometers" for steel containing 0.20% C are sketched in Fig. 56. The thermometers, it should be recalled, record experimental information that also is recorded on the equilibrium diagram.

The heating thermometer shows that at room temperature the soft steel consists of ferrite and iron carbide, which is called *cementite* by metallurgists and has the formula $Fe_3C$ (6.67% C). Cementite is a very hard, brittle substance, which, when it is distributed as minute particles through crystals of soft ferrite (alpha iron), strengthens it, in much the same way as reinforcing bars strengthen concrete.

When the steel reaches 720° C. on heating, all the cementite and part of the ferrite (alpha) undergo a *eutectoid* reaction. The product of the reaction is austenite (gamma). The reaction liberates heat which halts the rise in temperature, so that the eutectoid reaction starts at 720° C. and is completely austenitic.

**Fig. 57—Three Stages in the Cooling of Austenite in 0.20% C Steel**

Left—Coarse austenite crystals above 850° C. showing twins

Middle—A little below 850° C. showing ferrite grains growing in the grain boundaries of the austenite and along twin boundaries

Right—A trifle above 720° C. showing continuous boundaries of ferrite (shaded) surrounding austenite grains, which have ferrite bands through them. After passing through 720° C. the austenite changes to pearlite

Above 850° C. the austenite crystals grow, which implies that many small austenite crystals are coalescing to form fewer large austenite crystals. At 1490° C., melting commences and continues until at 1520° C. the last crystal of austenite melts.

The events recorded on the cooling thermometer are familiar until the temperature has fallen to 850° C. The freezing of steel was discussed in the chapter dealing with the weld melt.

Crystals of austenite appear in the weld melt at 1520° C. on cooling. As the temperature is lowered, the proportion of austenite crystals in the melt increases; that is, the melt becomes mushy. At 1490° C. the last drop of liquid crystallizes. Our microscope reveals that there is no change in the austenite crystals until the temperature has fallen to 850° C.

In the same way as crystals separate from the melt at 1520° C., so at 850° C. ferrite crystals separate from the austenite (refer to the section entitled "How Crystals Grow from Other Crystals"). The nuclei of the ferrite crystals are principally at the grain boundaries of the

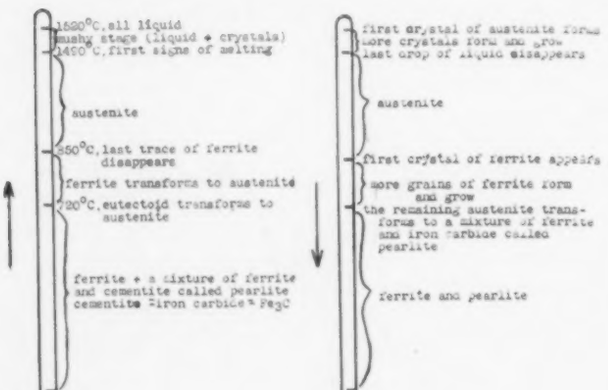

1520°C, all liquid
mushy stage (liquid + crystals)
1490°C, first signs of melting
austenite
850°C, last trace of ferrite disappears
ferrite transforms to austenite
720°C, eutectoid transforms to austenite
ferrite + a mixture of ferrite and cementite called pearlite
cementite iron carbide = Fe3C
Heating
first crystal of austenite forms
more crystals form and grow
last drop of liquid disappears
austenite
first crystal of ferrite appears
more grains of ferrite form and grow
the remaining austenite transforms to a mixture of ferrite and iron carbide called pearlite
ferrite and pearlite
Cooling

**Fig. 56—"Thermometers" for Steel Containing 0.20% Carbon**

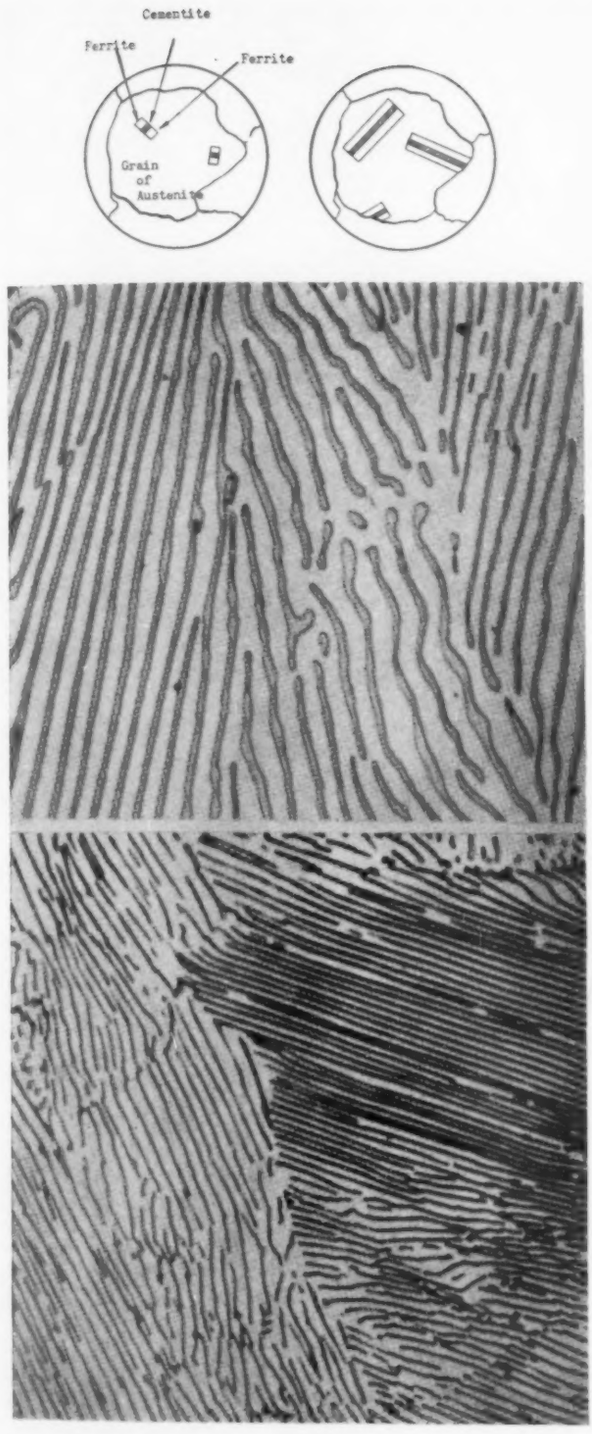



**Fig. 58—Stages in the Formation of Pearlite from Austenite**

The sketches are diagrammatic and the cementite is cross hatched
(a) Top Left—cementite and ferrite nuclei appear in a grain of austenite
(b) Top Right—later stage in the euctectoid reaction. The nuclei grow in only one plane to form plates. Other nuclei form on either side of the initial nuclei
(c) Middle—coarse pearlite (Aborn)
(d) Bottom—medium pearlite (Aborn)

austenite crystals, Fig. 57. The ferrite crystals grow as the temperature continues to fall until, a trifle above 720° C., one-quarter of the steel is austenite, the remaining three-quarters is ferrite. The geometrical pattern of ferrite within the austenite grains is called Widmannstätten structure. It is a structure resulting from the cooling of large austenite grains, and is usually found in single-pass welds in mild steel. It is not the most ductile form in which 0.20% C steel can occur.

Cast steel and overheated wrought steel generally have Widmannstätten structure, which accounts for their comparatively low notch impact value, particularly at low temperatures. Whereas a fine-grained mild steel weld metal may have a Charpy notch impact value of 20 ft.-lb. at −100° C., a steel of the same composition but composed of coarse grains with Widmannstätten structure may have only 2 ft.-lb. Charpy. Widmannstätten structure is not confined to steel, but may occur in any alloy in which a crystal is precipitated from a parent grain of different composition and lattice.

At 720° C. the austenite undergoes a curious change called the eutectoid. The change is started by the formation of nuclei of iron carbide (called cementite = $Fe_3C$) at several points in each austenite crystal. At once, the austenite, which now contains 0.8% C owing to the separation of large quantities of carbon-free ferrite, liberates nuclei of ferrite as well, as a result of the eutectoid change: austenite → cementite + ferrite (on cooling). The reaction liberates heat which maintains the steel at 720° C. until all the austenite has changed to ferrite and iron carbide.

During the reaction, the ferrite and cementite nuclei, for some unknown reason, grow in only one plane to form alternate plates of ferrite and cementite, Fig. 58. The structure we see in the microscope below 720° C. thus consists of alternate plates of cementite and ferrite, and is called pearlite. Below 720° C. the 0.20 C steel cooled slowly from the melt consists principally of ferrite grains with fewer pearlite grains. The ferrite occurs partly as grains outlining the initial austenite grains, partly as grains forming the geometrical Widmannstätten structure within what were initially austenite

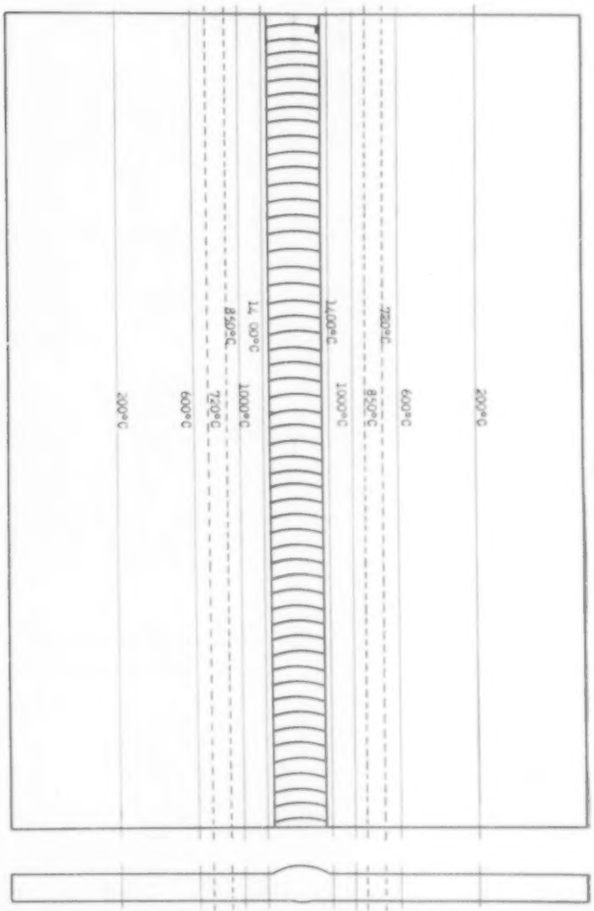


**Fig. 59—Distribution of Maximum Temperatures in Welding a Steel Plate**

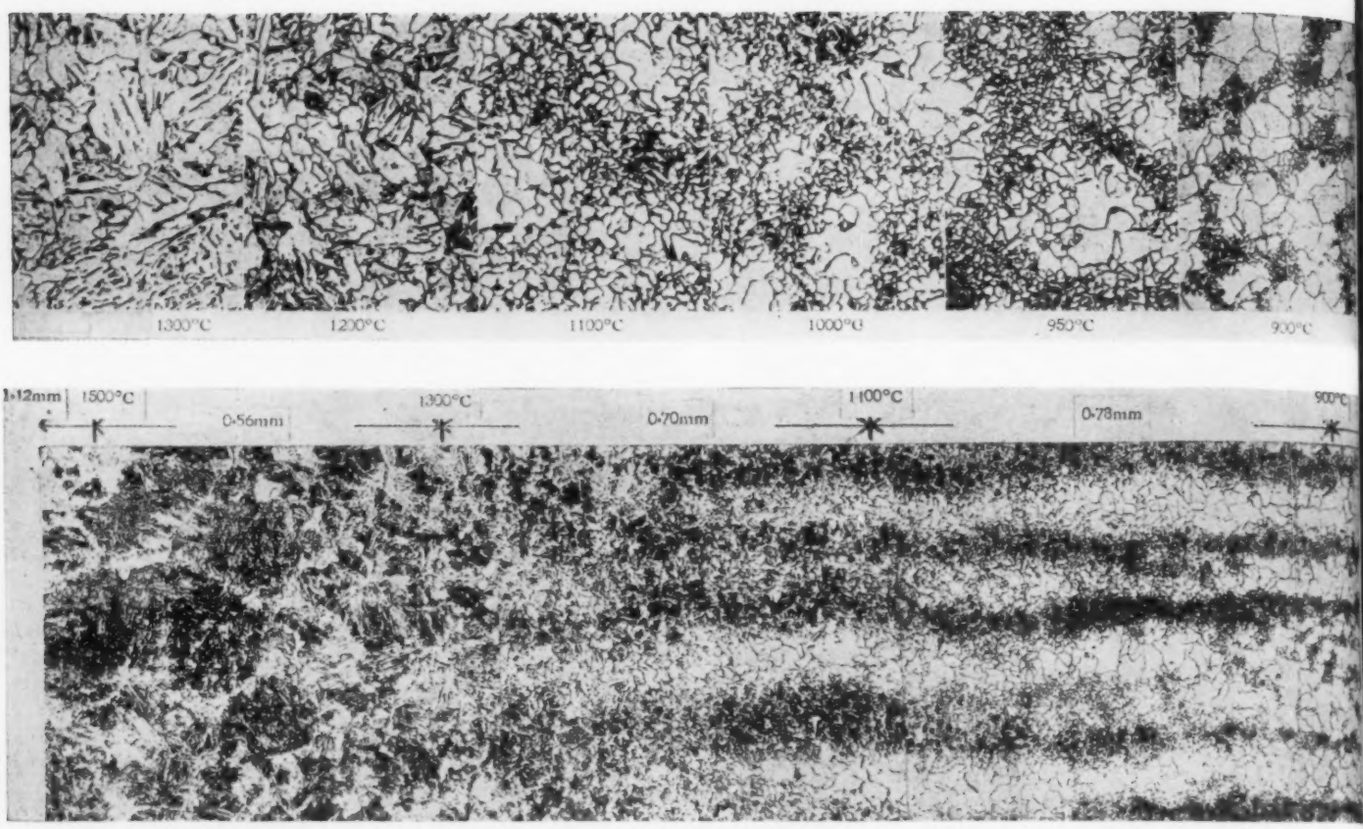



**Fig. 62—Change in Microstructure of Mild Steel as it Approaches the Weld Metal at the Left. Note Banding of Pearlite in Base Metal and How the Banding Disappears Near the Weld**

The upper row of photographs shows the change in microstructure of unbanded mild steel as it is heated to successively higher temperatures. (Okada)

grains, and partly as minute plates in the pearlite. Whereas the Widmannstätten structure is readily distinguished at comparatively low magnifications (50 diameters), the individual plates of ferrite and pearlite can be distinguished only at high magnifications (500 diameters).

How has carbon strengthened the steel? Most of the 0.20% C steel consists of ferrite, which is practically pure iron. However, the small proportion of iron carbide is fairly uniformly distributed throughout the steel and effectively blocks widespread slip on the slip planes of the ferrite. Since slip is restricted, the strength is raised but the ductility is decreased.

Having discussed what happens to 0.20% C steel on being heated to the molten state and slowly cooled, we revert to the weld. Figure 59 shows the maximum temperatures attained in all parts of the plates during welding and corresponds with the similar sketch for the pure iron weld. The weld metal has cooled slowly from the molten state and therefore has a Widmannstätten structure, which is not the most ductile structure possible. All parts of the plates between the weld and the line representing a maximum temperature of about 1100° C. also consists of large gamma grains when the weld melt was nearby and cooled to form a Widmannstätten structure.

However, our microscope reveals that the portion of the plates that have been heated not over about 1100° C. but above 850° C. do not have Widmannstätten structure. Instead, the structure consists of small grains of ferrite among which are distributed small grains of pearlite, Fig. 60. The reason the Widmannstätten structure did not form is that the austenite grains were too small. As in the coarse grains, ferrite nuclei form both at the grain boundaries and along twin planes in the austenite grains below 850° C. The ferrite crystals within the small austenite grains quickly coalesce with the ferrite crystals at the boundaries. In this way the boundaries of the initial austenite grains are obliterated. The resulting structure is more ductile and more desirable than the Widmannstätten structure.

The next area of the welded mild steel plate which we shall examine is that which has been below 850° C. but above 720° C. when the weld melt was nearby. Before welding, the plates had the structure shown in Fig. 61, left, which is typical of mild steel plate containing 0.20% C. The white grains are ferrite (alpha iron). The dark grains containing alternate plates of ferrite and cementite are pearlite.

Upon reaching 720° C., the pearlite grains transform to austenite containing the same amount of carbon as pearlite, namely 0.80%. As the temperature rises, the austenite absorbs (dissolves) some of the ferrite in its vicinity. If the temperature rose to 850° C., all the ferrite would be dissolved and only austenite would be present.

We are considering the region of the welded plate that has not been heated as high as 850° C. After the temperature has risen to 800° C., for instance, the structure will have the appearance shown in Fig. 61, middle. When the

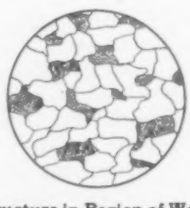
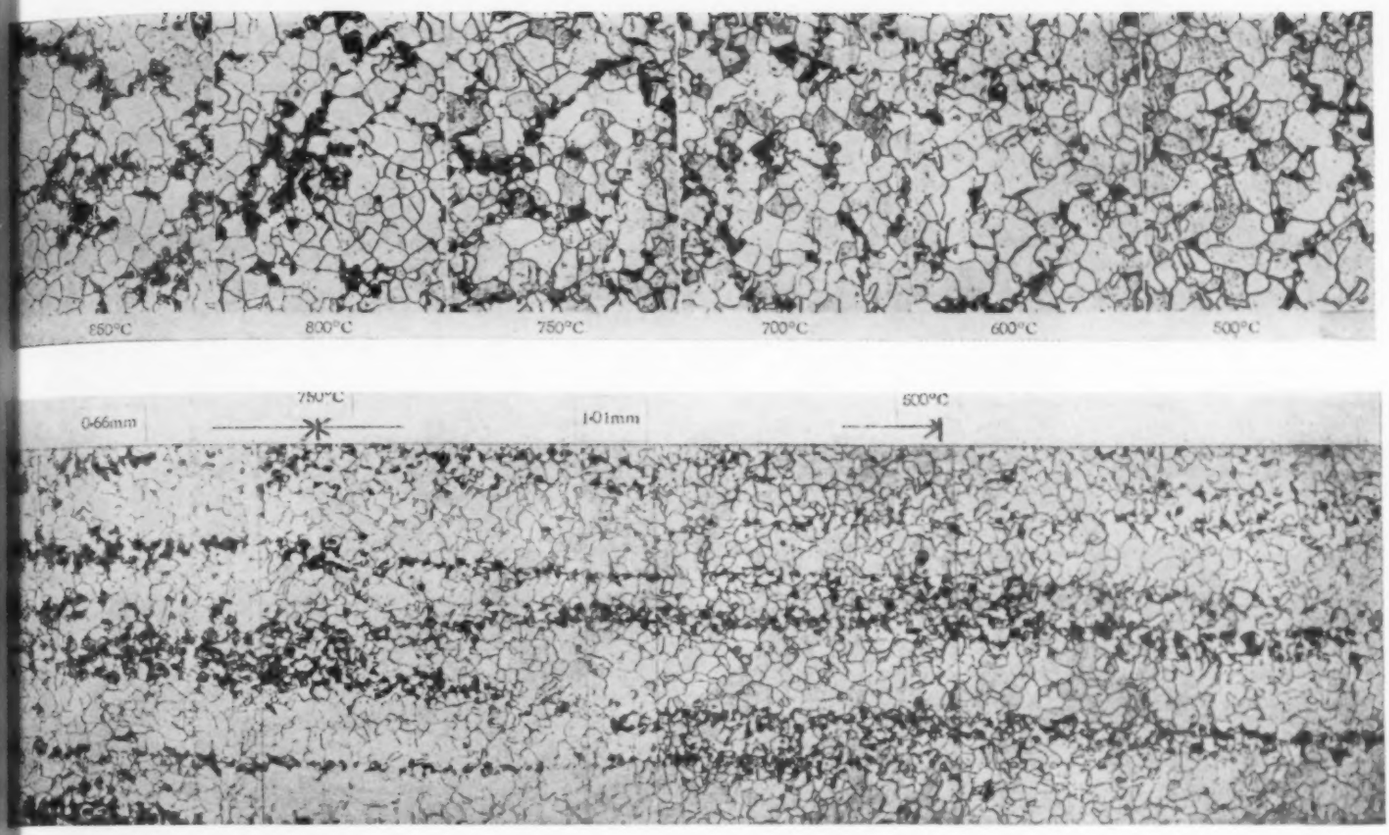


**Fig. 60—Fine Grained Structure in Region of Weld That Has Been Heated to About 850–1100° C. Small Grains of Ferrite and Pearlite**




steel is cooled, small ferrite grains separate and at 720° C. the remaining austenite, now containing 0.80% C, transforms to pearlite as shown in Fig. 61, right. The region that has been heated below 850° C. but to at least 720° C. during welding, therefore consists of relatively coarse ferrite grains that have not been completely dissolved and of much finer clusters of ferrite and pearlite grains occupying the region previously occupied partly by comparatively large pearlite grains.

There remains one region that we have not discussed: the region that has not reached 720° C. during welding. The grains have not changed in size or shape or crystal structure. There is a tendency for the iron carbide heated just below 720° C. to coalesce into larger particles (spheroidized). The speed of welding usually is so high that spheroidization of the cementite in the pearlite is scarcely ever observed. Of course, if the weld subsequently is stress annealed at 600° C., the cementite may spheroidize to a small extent. If the steel has been cold worked before welding, for example, bent in a brake, the ferrite grains will recrystallize at 500 to 600° C.

**Fig. 61—When Mild Steel Is Heated Between $A_1$ and $A_2$ the Pearlite Changes to Austenite at $A_1$ and, Upon Further Rise in Temperature, Absorbs Some of the Adjacent Ferrite. When the Steel Is Cooled, Small Grains of Ferrite Appear in Each Grain of Austenite Until at $A_1$ the Remaining Austenite Changes to Pearlite**

Left—Before heating (high magnification)
Middle—After heating above 720° C., the austenite grains have absorbed some of the neighboring ferrite. The austenite grains contain less than 0.8% C.
Right—After cooling below 720° C. The austenite containing, say 0.50%C., has transformed to a mixture of fine grains of ferrite and pearlite

The pearlite grains remain distorted until the cementite dissolves at 720° C.

Comparing the single-pass weld in pure iron with the single-pass weld in mild steel we see that:

1. The pure iron weld melt solidifies at a single temperature, whereas in mild steel freezing occurs over a range of temperatures, which is favorable to evolution of gases.
2. The pure iron must be heated above 900° C. before any change in grain size occurs, whereas in mild steel the pearlite grains change at 720° C.
3. The range of temperatures over which the change from ferrite to austenite occurs in mild steel gives rise to two types of structure; the Widmannstätten coarse-grained type, and the more ductile fine-grained type.

### The Two-Pass Weld in Mild Steel

Like the single-pass weld in pure iron, there are coarse grains in the weld and adjacent thereto in the single-pass weld in mild steel. By depositing a second bead after the first has cooled below 720° C. the coarse grains in the first bead are refined in the same way as in pure iron (refer to the section entitled "The Two-Pass Pure Iron Weld"). The two-pass weld in mild steel thus consists of a fine-grained lower bead and a coarse-grained upper bead. Consequently, the two-pass weld will have superior ductility.

### Full Annealing

If we wish to soften a welded steel as much as possible and to create a uniformly fine-grained structure throughout, we full-anneal it. Annealing, or full annealing as it is properly called, consists in heating the part about 50° C. (100° F.) above the critical temperature range;

that is, the range in which ferrite changes to austenite. For 0.20% C steel the full annealing temperature is 850 + 50 = 900° C. The temperature is held 1 hour for each inch of section of the heaviest parts being treated. Ordinarily the parts are cooled in the furnace or in some substance yielding a slow rate of cooling, such as ashes. Welded parts are seldom full annealed, because extreme softness is undesirable and the parts, such as tanks or boilers, may sag out of shape at a bright red heat. Any coarse-grained zone in the vicinity of the weld is refined by full annealing.

### Stress Annealing

Welded high-pressure piping, pressure vessels and similar parts frequently are stress annealed in order to eliminate shrinkage stresses. Plain-carbon and low-alloy steels generally are stress relieved at 550–600° C. (1100–1200° F.) for 4—1 hr. per inch of thickness. Stress annealing may or may not have important effects on the structure of the welded part, depending on the steel and the rate of cooling after welding.

### Questions

1. In what ways does the second layer change the structure of the first bead of weld metal on iron? How does the second layer alter the heat-affected zone produced by the first layer?
2. Show how a small amount of carbon, say 0.2%, added to iron changes the structure of a weld in the metal.
3. Show the difference between Widmannstätten structure and the structure consisting of extremely small grains of ferrite and pearlite in the heat-affected zone of welds in mild steel.

---

## COAL BARGE

New efficiency in the deep water transport and unloading of coal is being demonstrated by the "Electric 21," welded-steel coal barge recently placed in harbor service by the Oliver Transportation Company of Philadelphia, Pa. According to R. K. Walling, manager of the company, this steel barge with a load capacity of 2755 tons requires no more power for towing than a 1500-ton wooden barge.

Built by Dravo Corporation, this barge was designed to use a parabolic rake, which is unusual for harbor coal carriers. Its dimensions are 170 by 40 by 17 feet, making it the largest all-welded steel barge yet designed for harbor coal transport.

Despite its large size, the hopper of the barge has only two cross members, thus allowing for free and facile digging of the entire load. As a result, unloading time and maintenance costs are reduced. The cross members are of welded box construction, $^3/_4$-inch plate being used, with vertical and diagonal stiffener bars providing internal reinforcement. The bottom and side slopes of the hopper are fabricated from one-inch plate, also given special reinforcement to produce ruggedness and protection from bucket damage.

The towing performance of the barge confirms the findings of Dravo engineers with pretested rake end designs. Tank tests with models under deep draft towing conditions show that a barge of this design and approximate size can be towed at the normal speed of 5 knots with about 55 to 65 per cent of the power, per ton of displacement, required for barges of conventional design.

Where no length restrictions are imposed by operating or docking conditions, the additional length of rake ends to secure maximum ease of towing is fully justified by the reduction in power required for towing. Only by giving consideration to such related factors, and through experimentation with scientifically engineered rake end designs, can maximum towing efficiency be reconciled with extreme load capacity.

Fig. 1—Recently Placed in Harbor Service by the Oliver Transportation Company, This 2755-Ton Barge Is the Largest All-Welded Steel Barge Yet Designed for Harbor Coal Transport

Fig. 2—A Feature of Dravo's Construction Was the Use of the Union Melt Automatic Welding Process. Here the Automatic Welder Is Being Used to Join Side Sections—Which Are Later Lifted in One Piece for Final Assembly

In constructing the barge, initial fabrication was performed at Dravo's Neville Island shops, Pittsburgh, Pa. Assembly and launching were done at the Wilmington, Del., shipyard.

The construction procedure followed the now well-known Dravo "line assembly" routine. Manual arc welding was used in the shop fabrication with the welds on the details being of the fillet type. When the shop work was completed, the subassemblies were shipped by rail to the Wilmington shipyard.

The final assembly was marked by the extensive use of the Union Melt automatic welding process. The use of this welding method is illustrated in Fig. 2, which shows the joining of prefabricated sections forming one of the barge sides. All of the side plating in the Wilmington operations was welded by this method.

A number of structural details are important because their objective is to give general ruggedness and damage-resisting strength to this steel coal barge. Dravo has carried the rounded corner a step farther with a patented reinforcing and stiffening of the corner plates, thereby providing strong inside construction; on the outside, a heavy reinforcing plate gives protection to the corner.

The headlog is flanged over the deck plate and under the rake plate. It is further strengthened by a heavy horizontal stiffener angle which is backed up by a vertical channel at each rake frame. Rake frame strength is increased by the use of transverse trusses in addition to the longitudinal rake truss system. Serrated framing increases the general structural strength. The welding is done all around the serration contacts, producing a strong pedestal base at each connection. This solid base leaves no open surface to be attacked by corrosion whereas the serrated framing leaves a free channel for the flow of bilge water, air or gases.

# WELDING FOR ENAMELING*

By JOSEPH C. LEWIS†

THE problem of "welding for enameling" or welding steel parts for enameling is neither as complicated as one would be led to believe, nor is there any mystery about the process or procedure. In this discussion, I am going to stay away from as many of the technical phases of the problem as possible, but at the same time try to bring out the important steps involving the effective application of porcelain enamel to light metal parts after they have been fabricated or assembled by the process of acetylene welding.

The application of porcelain enamel to sheet metal, in colors and particularly pastel shades requires a finish which will not high light or show any irregularities of the steel base. This of necessity demands that welded parts have smooth well-finished contours and surfaces. Surfaces which have been hammered or are uneven as a result of excessive drawing operations are extremely difficult to cover over in enameling and usually are rejected on or before final inspection because of unsatisfactory finish. It is much easier and the cost is lower if the part or parts to be welded for the final assembly are made with the simplest possible operations, then assembled on fixtures designed for acetylene welding and finished in such a manner that they can be properly cleaned.

In this brief talk, I shall try to present some of the problems which were encountered and overcome in developing the process of manufacturing tanks and tubs used in the assembly of home laundry machines. I believe, that because of the number of factors which enter into the production of this particular item that a brief description of the method used in its manufacture will clearly show the advantage and simplicity of using the acetylene welding process as compared with conventional stamping and deep drawing methods, including rolling, trimming, etc. By advantages, I mean lower manufacturing costs, less capital investment and a superior product.

To begin with, let us consider the type of washing machine tub, and the kind and number of machines required for its manufacture, also the factory space required.

A shop area of approximately 7500 square feet will handle the manufacture and assembly of 200 tubs per day and allow ample room for the storage of stock, as well as the placement of the squaring shear, blanking and punch press, flattening press, rotary shear, welding fixtures, hammer, grinder, corrugating rolls and final inspection. Another 7500 square feet will be required for the enameling of the 200 tubs per day, including the pickling and cleaning department, mill department for making the enamel, oven firing of the finish, drying tunnel and spray booth with sufficient space for the inspection and storage of a nominal quantity of finished units. In other words, a plant with a floor area of 100 feet by 150 feet, partitioned in two departments by a light wall can produce 5000 washing machine tubs per month, on the basis of an 8-hour day, 40-hour week. Reduced to dollars, this amounts to a monthly sales values at nominal average selling price to the washing machine manufacturer of approximately $15,000.00. Operating on a 24 hour basis, the production of this size of plant could reasonably be increased to 15,000 units per month with a very substantial reduction in manufacturing costs due to full time utilization of heating ovens and other facilities.

The tub or tank consists of two parts; one, the side wall, made by rolling a flat metal sheet into a cylinder with a butt-welded seam. The flat sheet must be properly squared so that when it is rolled into a cylinder and closed by welding, it will have an accurate edge to which the bottom, in turn, can be welded. This is especially important. The other part, the tub bottom is struck and formed in a single operation from either strip steel or a circular blank. In this same operation, a radius is turned up around the bottom so that the bottom and side wall can be properly joined for welding. Any drain or other holes required in the bottom of the tub are punched out in this same operation.

Following this blanking and piercing operation, the tub bottom is sheared. A circular shear is used which must be accurately set to give a true and square edge to facilitate the following welding and assembly operations. We now have the bottom part with a turned up flange or radius, in most cases about $^{7}/_{8}$ of an inch, ready to set and weld to the tub side wall which has been seamed.

The blowpipe, in the welding apparatus on the seaming fixture for the cylinder is equipped with multiple tips, the proper size and number depending upon the thickness of the metal as well as the speed at which the fixture operates. More elaborate equipment is required for high speed production than if the plant is set up only at what might be called a more or less normal production rate. This feature is decidedly in favor of welded assemblies as the capital investment can be kept consistent with production, eliminating expensive drawing and forming equipment. Immediately ahead of the welding torch, traveling at identically the same speed as the torch, is a positioning wheel, which guides the blowpipe along its proper course. The operator merely regulates the flow of gas to the torch.

The most common depth of tub used in the manufacture of a washing machine is about fourteen inches for which the actual welding time is about 22 seconds. Including the welding and placing the cylinder in the fixture, and its removal after welding, the total time is approximately one minute. To decrease the time required for welding and handling, we have developed a water cooled jig with an automatic clamping device which is operated as a turret head, using welding appara-

*Paper presented at the 40th Annual Convention, International Acetylene Association, April 10, 11, and 12, 1940, Milwaukee, Wisconsin.
†President, Associated Engineers, Inc., Fort Wayne, Indiana.

tus which will produce 120 complete cylinders per hour with one welder and one helper. In welding the side walls or cylinders no welding rod is used.

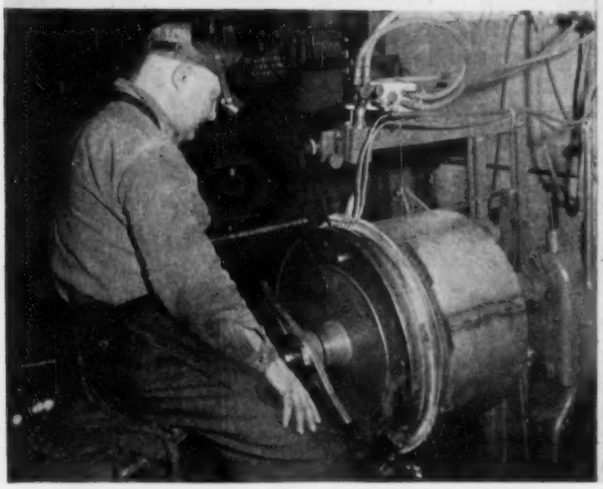
The next step in the operation is to place the cylinder on the welding fixture, and snap the bottom part over the fixture in position against the cylinder. The fixture should be so constructed as to flare out the radius flange. The cylinder is held in place in the welding fixture by a quick acting clamping ring which allows the bottom stamping to be placed against the end of it in such a manner as to secure a pressure contact entirely around the edges of the tub cylinder and the stamped bottom. The wall of the tub is set in the fixture in such a manner as to hold the two parallel edges solidly together, in other words, a certain amount of pressure is exerted to keep the parallel edges together. At this point, I want to stress the extreme importance of having proper clamping fixtures of sufficient weight to not only rigidly hold the work but carry the heat rapidly away as well. Welding fixtures must be designed to permit easy control of the speed of welding and careful regulation of gas to the blowpipe. Where advisable the fixture must also provide for water cooling of the blowpipe. Welding fixtures must also be readily adaptable to changing models as well as capable of handling sample tubs or other parts frequently required by Sales Departments. Again we find the flexibility of a correctly designed and operated welding process a distinct advantage from an economy standpoint, an important sales assistance.

In order to clarify the welding process, let us go back to where the cylinder has been placed on the expanding type welding fixture in an horizontal position with the bottom of the tub snapped over the fixture and the clamping device tightened. We now have a unit ready for welding with a crevice approximately $1/2$ inch wide around the bottom periphery, with the edges of the bottom of the tub or side wall or tube, clamped tightly together. During the welding operation, the fixture remains cool merely through the absorption and dissipation of heat through the fixture and connections, providing the required number of units to be welded is comparatively moderate with respect to over-all parts. If, however, large quantities are to be welded, water cooled equipment should be used, because of the necessity of dissipating the heat, generated by the use of water cooled multiple tip torches, as well as the high speed of the fixture.

Water cooled, air operated fixtures have been designed

Fig. 1—This View Shows the First Step in the Production Welding of Home Laundry Machine Tubs Prior to Enameling. A Fixture Holds the Sheet Metal Firmly in Position While the Weld Is Made Automatically. The Heavy Fixture Also Serves to Carry Away the Heat Rapidly

Fig. 2—Close-Up of the Operation Shown in Fig. 1. Immediately Ahead of the Welding Blowpipe Is a Positioning Wheel Which Guides the Flames Along Their Proper Course



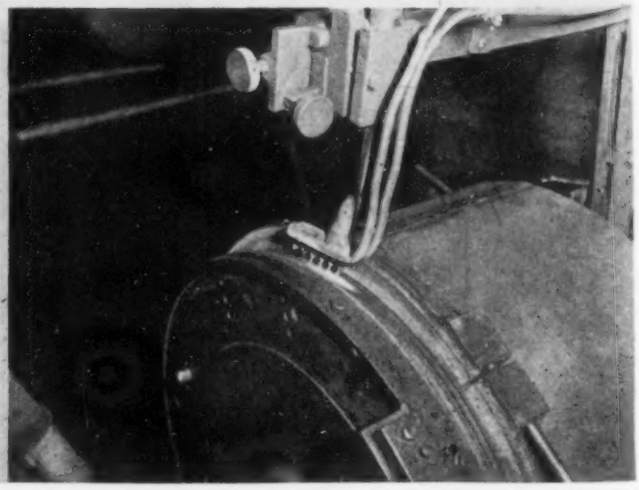


Fig. 3—A Second Fixture Is Used to Hold the Flanged Tub Bottom in Position for Welding to the Tub Bottom. The Cylinder Is Held in Place in the Welding Fixture by a Quick Acting Clamping Ring to Secure Pressure Contact of the Bottom Against the Edges of the Tub Cylinder

Fig. 4—Close-Up of the Circumferential Weld. After Cleaning, the Weld Presents a Smooth, Well Finished Surface for Enameling

Fig. 5—The Shop Layout Is Well Designed for Repetitive Welding Operations

for producing 23-inch tubs, requiring a weld of approximately 78 inches, welded with a six tip water cooled blowpipe traveling at the speed of about 42 inches per minute, making a complete weld in slightly less than 2 minutes. Approximately one minute is required to load and unload the fixture, but this time can be greatly reduced by applying an air operated loading device. The normal production from a manually operated fixture is about 20 units per hour, which can be increased to approximately 30 to 35 assemblies per hour with an air actuated fixture. It will be noted that in producing complete welded tanks or tubs, inexpensive manufacturing equipment is principally used. The cylinder blanks can be purchased to size or can be squared on a standard squaring shear. The bottom blank can be made on a single acting, double crank punch press with the use of either a spring sub-press or pressure pad to draw up the flanges. Such a press can be purchased at a small percentage of the cost of equipment which would be necessary to handle deep drawing operations up to 15 inches or more in depth. The finishing of these tanks or tubs ready for enameling, of course, depends on the type of tub required for the finished machine. Let us take for example, that which is commonly termed the bullet type tub, having a turned in flange or roll at the top to give a streamlined appearance. After the tubs are taken off the fixture that welded the bottom to the cylinder, it is sometimes necessary to reinforce the weld at the point where the horizontal weld crosses the vertical, as there is a tendency for a very small hole to be burned there. After producing many thousands of tubs, it has been found necessary to "spot," only about 20 per cent of the production. It is also necessary at the top edge of the tub, where the seam weld starts, to reinforce this weld with a "spot," using a welding rod in order to prevent a tear developing during the rolling operation which is quite severe. After this, the entire weld down the side of the tub and around the bottom is subjected to a quick normalizing or hammer operation using a high-speed vibrating hammer. This does two things; first, it relieves any strain which may have developed at the point of the weld and it also removes any oxidized metal from the welding.

The next operation is to place the welded tub in a grinding fixture which makes a sweep around the longitudinal and circular welds, after which the tub is now ready for the rolling or corrugating operations.

There are several important factors to watch in the fabrication of the tubs which, if carefully controlled, will reduce the cost of enameling.

1. Only a high quality of steel or iron of uniform specifications and analysis should be used.
2. The use of lubricants detrimental to the cleaning process should be prohibited.
3. The fabrication schedule should be carefully planned so that completed units move at once to the enameling department in order to avoid damage to tubs through storage or rehandling.

The first operation in corrugating is to place the tub in a fixture with a roll which revolves at a speed of about 30 revolutions per minute and rolls or forms the edges of the tub into a rounded rim about $^1/_2$ inch in diameter. The tub is then transferred to a corrugating machine which completes the rolling operation and turns the tub in or out at the top, as the case may be, besides adding what additional corrugations may be necessary, according to the design of the tub.

The total cost of direct labor involved in producing the tub, including blanking the bottom, squaring the sides, shearing the bottom blank, welding the tub, necessary spotting, hammering, grinding and corrugation, amounted to 19¢, based on an average rate for the operator of 85¢ per hour.

The tub is now ready to go to the enameling department and because the acetylene welding process is used, the enameling operation is greatly simplified. The metal of the tubs has not been distorted, as is often the case with deep drawing operations and sometimes by annealing and redrawing, there are no deeply embedded foreign substances from drawing compounds, etc. Therefore, the cleaning of the tubs preparatory to enameling is an easy, economical procedure. Because the operations can follow in rapid succession, the welded tub is a splendid example of the advantages and economies resulting from the proper use of the acetylene welding process on a large scale production. Manufacturing costs are much lower than if stamped and drawn parts are used.

On a job which included nine different tubs, made with various corrugations and enameled finishes, consisting of a total of 13,779 tubs, only 1138 or 8.3 per cent had to be reoperated and only 36, or a negligible percentage had to be scrapped. In other words, out of 13,779 tubs, 12,605 came through without having to be reoperated or touched up in any manner. Five hundred seventy-five of these tubs were mottled finish, 4970 were white, and the balance were green and grey. We are highly in favor of acetylene welding when materials are to be finished with porcelain enamels. Some of the parts which can be readily welded for enameling are refrigerator evaporators, liners, cabinets and parts, stove cabinets, liners and parts, display cases, electrical transformer cases, mixing tanks, etc.

In addition to the economies which can be effected in manufacturing costs, by the use of acetylene welding, there is still another advantage in that transportation costs of raw materials are less as the freight on flat sheets is much cheaper than it is on formed tanks or other parts that have been enameled, also, inventories can be kept at a minimum.

# *Tentative Specifications for*

# IRON AND STEEL ARC-WELDING ELECTRODES[1]

**Serial Designation: A 233 – 40 T**

ISSUED, 1940.[2]

This is a Tentative Standard and under the Regulations of the Cooperating Societies is subject to annual revision. Suggestions for revision should be addressed to the Headquarters of the A.S.T.M., 260 S. Broad Street, Philadelphia, Pa., or of the A.W.S., 33 W. 39th Street, New York, N. Y.

*These specifications were prepared jointly by the American Welding Society and the American Society for Testing Materials.*



## Scope

1. (*a*) These specifications cover lightly coated and covered metal arc-welding electrodes for the welding of carbon and low alloy steels of weldable quality.

NOTE.—In connection with the welding of low alloy steels the requirements of these specifications pertain to the tensile strength and elongation of the deposited metal and not to high- or low-temperature characteristics, creep properties, or corrosion resistance.

(*b*) The electrodes are classified on the basis of usability and the ultimate tensile strength of all-weld-metal specimens in the stress-relieved condition, as shown in Table I.

## Manufacture

2. The electrodes may be made by any methods that will yield a product conforming to the requirements of these specifications.

[1] Under the standardization procedure of the two Societies, these specifications are under the jurisdiction of the A.S.T.M. Committee A-1 on Steel, and of the A.W.S. Filler Metal Specifications Committee.

[2] Revision accepted by Committee E-10 on Standards, May 1, 1940.

These specifications were formerly issued under the serial designation A 205 and were published as tentative from 1937 to 1940.



## Standard Sizes and Lengths

3. Standard sizes and lengths of electrodes are as shown in the following table. In all cases, standard size refers to the diameter of the core wire.

| Standard Sizes, Diameter of Core Wire, in. | Standard Lengths, in. |
|---|---|
| $\frac{1}{16}$, 0.075, and $\frac{5}{32}$ | 9, 12, and 18[a] |
| $\frac{7}{64}$ | 12 |
| $\frac{1}{8}$ | 14 |
| $\frac{3}{32}$, $\frac{3}{16}$, $\frac{7}{32}$, and $\frac{1}{4}$ | 14 and 18 |
| $\frac{5}{16}$ and $\frac{3}{8}$ | 18 |

[a] In the case of 18-in. lengths of $\frac{1}{16}$-in., 0.075-in., and $\frac{5}{32}$-in. electrodes, center gripping of the electrodes is standard. In all other cases, end gripping is standard.

## Chemical Composition

4. The electrodes shall be capable of depositing metal conforming to the following requirement as to chemical composition:

| | |
|---|---|
| Sulfur, max., per cent | 0.04 |

## Chemical Analysis

5. The sample for analysis shall be prepared as follows: A specimen of standard base metal (see Section 13 (*a*)) of sufficient size, shall be prepared, and a pad of five superimposed layers of weld metal deposited thereon. The fifth or top layer shall be ground or machined away and discarded. The sample for chemical analysis shall be obtained from the third and fourth layers.



## Permissible Variations in Dimensions

6. (*a*) Covered electrodes for manual welding shall be bare or free from covering for a distance of about 1 in., but not more than $1\frac{1}{4}$ in., for making contact with the holder.

(*b*) The arc end of each electrode shall be sufficiently bare to permit easy striking of the arc, but the length of the bare portion of the arc end, measured from the end to the point where the full cross-section of the coating obtains, shall not exceed one core-wire diameter.

(*c*) The diameter of the core wire shall not vary more than plus or minus 0.002 in. from the standard size specified. The length shall not vary more than plus or minus $\frac{1}{8}$ in. from that specified.

(*d*) The covering on covered electrodes of all sizes shall be concentric to the extent that the maximum core-plus-one-covering dimension shall not exceed the minimum core-plus-one-covering dimension by more than 3 per cent. The concentricity shall be measured as follows:

The covering shall be removed from one side of the electrode (care being taken to insure that no metal is removed from the core) at about the middle of its length. The core-plus-one-covering dimension (which is the diameter of the core plus the thickness of the covering on one side) shall be measured with a micrometer. The covering shall be removed from the opposite side of the electrode at a point distant from the place where the covering was previously removed, and a similar measurement made. Two more pairs of measurements of the core-plus-one-covering dimension shall be made on planes at angles of 60 and 120 deg. from the plane of the former measurements. The pair of measurements which shows the greatest percentage of variation shall be used in determining the acceptability of the electrode.

## Electrode Coverings

7. (*a*) The coverings shall, when cool, have sufficient electrical resistance to effectively insulate against a difference of potential of 100 v.

(*b*) The slag produced shall be readily removable.

## Workmanship

8. (*a*) Lightly coated electrodes and the core of covered electrodes shall be of uniform quality and free from injurious segregation, oxides, pipe, seams, or other irregularities.

(*b*) On covered electrodes, the coverings shall be such that they are not readily damaged by ordinary handling and shall be of commercially uniform thickness and shall present a workmanlike appearance. Coverings shall be free from injurious scabs, blisters, abnormal pockmarks, bruises, or other surface defects.

## Finish

9. The surface of lightly coated electrodes and the core of covered electrodes shall be smooth and free from harmful scale, oil, or grease.

## Packing

10. Electrodes shall be suitably packed, wrapped, boxed, or crated to insure against injury during shipment or storage, as follows:

(*a*) Bundles of 50 lb. net weight,

(*b*) Boxes of 25 or 50 lb. net weight, and

(*c*) Coils or reels of approximately 150 or 200 lb. net weight.





(2) Standard Specifications for Steel

These specifications were formerly issued under the serial designation A 205 and were published as tentative from 1937 to 1940.

of five superimposed layers of weld metal deposited thereon. The fifth or top

mension shall be made on planes at angles of 60 and 120 deg. from the plane

(*c*) Coils or reels of approximately 150 or 200 lb. net weight.



TABLE I.—TENSILE REQUIREMENTS OF DEPOSITED METAL.

| Electrode Classification Number | Capable of Producing Satisfactory Welds in Positions Shown[c] | General Description | Treatment of Welded Specimen[a] | Tensile Requirements of Material Deposited from 5/32, 3/16, and 7/32-in. Electrodes[b] | |
|---|---|---|---|---|---|
| | | | | Tensile Strength, min., psi. | Elongation in 2 in., min., per cent |
| E7010 | V, F, OH, H | Heavy covering, useful with d.c., electrode positive only. | SR<br>NSR | 70 000<br>75 000 | 22<br>17 |
| E7011 | F, V, OH, H | Heavy covering, useful with d.c., either polarity, or with a.c. | SR<br>NSR | 70 000<br>75 000 | 22<br>17 |
| E7020 | H-Fillets, F | Heavy covering, usually used with electrode negative or a.c. for fillets, or electrode positive or a.c. for flat welding. | SR<br>NSR | 70 000<br>75 000 | 25<br>20 |
| E7030 | F | Heavy covering, usually used with electrode positive d.c. or with a.c. | SR<br>NSR | 70 000<br>75 000 | 25<br>20 |
| E6010 | F, V, OH, H | Heavy covering, useful with d.c., electrode positive only. | SR<br>NSR | 60 000<br>65 000 | 27<br>22 |
| E6011 | F, V, OH, H | Heavy covering, useful with d.c., either polarity, or with a.c. | SR<br>NSR | 60 000<br>65 000 | 27<br>22 |
| E6012 | F, V, OH, H | Heavy covering, usually used with electrode negative, d.c. or on a.c. | SR<br>NSR | 60 000<br>65 000 | 22<br>17 |
| E6013 | F, V, OH, H | Heavy covering, usually used on a.c. | SR<br>NSR | 60 000<br>65 000 | 22<br>17 |
| E6020 | H-Fillets, F | Heavy covering, usually used with electrode negative or a.c. for fillets, and electrode positive or a.c. for flat welding. | SR<br>NSR | 60 000<br>65 000 | 30<br>25 |
| E6030 | F | Heavy covering, usually used with electrode positive on d.c., or with a.c. | SR<br>NSR | 60 000<br>65 000 | 30<br>25 |
| E4510 | F, V, OH, H | Wire with coating applied before drawing. | NSR | 45 000 | 5 |
| E4511 | F, V, OH, H | Wire with light coating applied after drawing. | NSR | 45 000 | 5 |
| E4520 | H-Fillets, F | Wire with coating applied before drawing. | NSR | 45 000 | 5 |
| E4521 | H-Fillets, F | Wire with light coating applied after drawing. | NSR | 45 000 | 5 |

[a] The abbreviations SR and NSR signify stress-relieved and non-stress-relieved, respectively. Stress-relieving when prescribed in these specifications is for the purpose of developing the fundamental properties of the weld metal unaltered by locked-up stress. Values obtained from stress-relieved welded specimens are about 5 per cent lower in tensile strength and 10 to 20 per cent higher in elongation than those of non-stress-relieved specimens. The fact that an electrode test requires stress-relief signifies only that it must develop the strength required regardless of stress-relief, and not that stress-relief must always be used in actual work. Stress-relieving shall be within the range of 1150 ± 25 F. for 1 hr. per inch of thickness. Specimens shall be heated at the rate of 300 to 350 F. per hr. and cooled at the same rate to 300 F. No specimen shall be heated for less than 1 hr.

[b] The tensile strength of the deposited metal from 5/32-in. electrodes shall be 105 per cent of that prescribed in Table I, and that from 1/4-in. and larger electrodes shall be 95 per cent of the tensile strength prescribed in Table I.

The elongation of the deposited metal from 5/32-in. electrodes shall be 90 per cent of that prescribed in Table I, and that from 1/4-in. and larger electrodes shall be 110 per cent of the elongation prescribed in Table I.

[c] The abbreviations F, V, OH, H, and H-Fillets indicate welding positions, as follows:

F—Flat
V—Vertical
H—Horizontal
OH—Overhead
H-Fillets—Horizontal Fillets

## Marking

11. All bundles, boxes, coils, or reels shall be legibly marked with the following information:

(*a*) Classification,

(*b*) Manufacturer's name and trade designation,

(*c*) Standard size and length, (weight



instead of length in case of reels and coils), and

(*d*) Guarantee.

## Guarantee

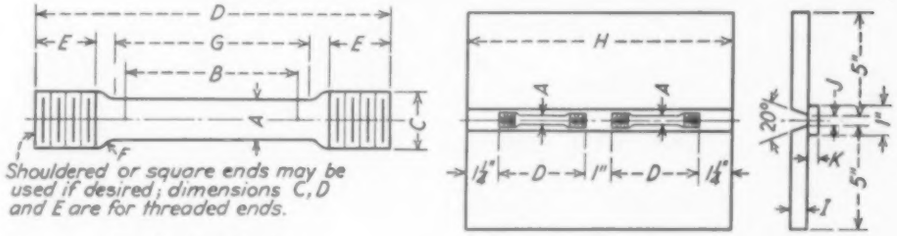
12. The manufacturer shall make tests at frequent intervals in accordance with the methods prescribed in these specifications, and shall guarantee that the electrodes in all sizes and classes conform to these specifications and each container shall be so marked.

(*2*) Standard Specifications for Steel for Bridges and Buildings (A.S.T.M. Designation: A 7),[4] open-hearth or electric-furnace steel.

(*b*) For electrodes smaller than 1/8 in., the all-weld-metal tension test is not practical and the strength of these sizes shall be judged by the strength of 1/8-in. or larger electrodes of the same classification.

(*c*) For electrodes 1/8 in. and larger a test plate shall be prepared as shown in

| Electrode Size, in. | Test Plate Thickness, in. I | Number of Layers | Diameter of Tension Test Specimen, in. A | Dimensions of Test Plate and Tension Test Specimen, in. B | C | D | E | F | G | H | J | K | Time to Wait after Depositing Pass and Before Pre-Heating for Next Pass |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/8 | 1/2 | Each Layer or Pass not to Exceed 1/8 in. in Thickness. | 0.252 ± 0.005 | 1 | 3/8 | 2 1/2 | 1/2 | 3/16 | 1 1/4 | 8 1/2 | 1/4 | 1/4 | 10 min. |
| 5/32 | 3/4 | | 0.500 ± 0.01 | 2 | 3/4 | 4 1/8 | 3/4 | 3/8 | 2 1/4 | 12 | 5/8 | 3/8 | 15 min. |
| 3/16 | 3/4 | | 0.500 ± 0.01 | 2 | 3/4 | 4 1/8 | 3/4 | 3/8 | 2 1/4 | 12 | 5/8 | 3/8 | 15 min. |
| 7/32 | 3/4 | | 0.500 ± 0.01 | 2 | 3/4 | 4 1/8 | 3/4 | 3/8 | 2 1/4 | 12 | 5/8 | 3/8 | 15 min. |
| 1/4 | 1 | | 0.500 ± 0.01 | 2 | 3/4 | 4 1/8 | 3/4 | 3/8 | 2 1/4 | 12 | 5/8 | 1/2 | 20 min. |
| 5/16 | 1 1/4 | | 0.500 ± 0.01 | 2 | 3/4 | 4 1/8 | 3/4 | 3/8 | 2 1/4 | 12 | 5/8 | 1/2 | 25 min. |
| 3/8 | 1 1/2 | | 0.500 ± 0.01 | 2 | 3/4 | 4 1/8 | 3/4 | 3/8 | 2 1/4 | 12 | 5/8 | 1/2 | 30 min. |




Tension Test Specimen. Test Plate Showing Location of Test Specimens.

FIG. 1.—Requirements for Preparation of Test Specimens.

## Guarantee Tests

13. For guarantee purposes, tests shall be made as prescribed in the following Paragraphs (*a*) to (*g*).

(*a*) The steels to be used for test plates shall conform to either of the following specifications of the American Society for Testing Materials:

(*1*) Standard Specifications for Carbon-Steel Plates for Stationary Boilers and other Pressure Vessels, (A.S.T.M. Designation: A 70).[3]

Fig. 1. The plate shall be insulated from the welding bench by 1/2 in. of asbestos during welding. After the joint has been tacked, the assembly shall be heated in boiling water for 5 min. prior to welding. After depositing each pass, the plate shall be left on the asbestos to cool in still air for the length of time prescribed in Fig. 1. Then, immediately, the plate shall be immersed in boiling water for 5 min. and the work continued. After the last pass, the

[3] 1939 Book of A.S.T.M. Standards, Part I, p. 41.

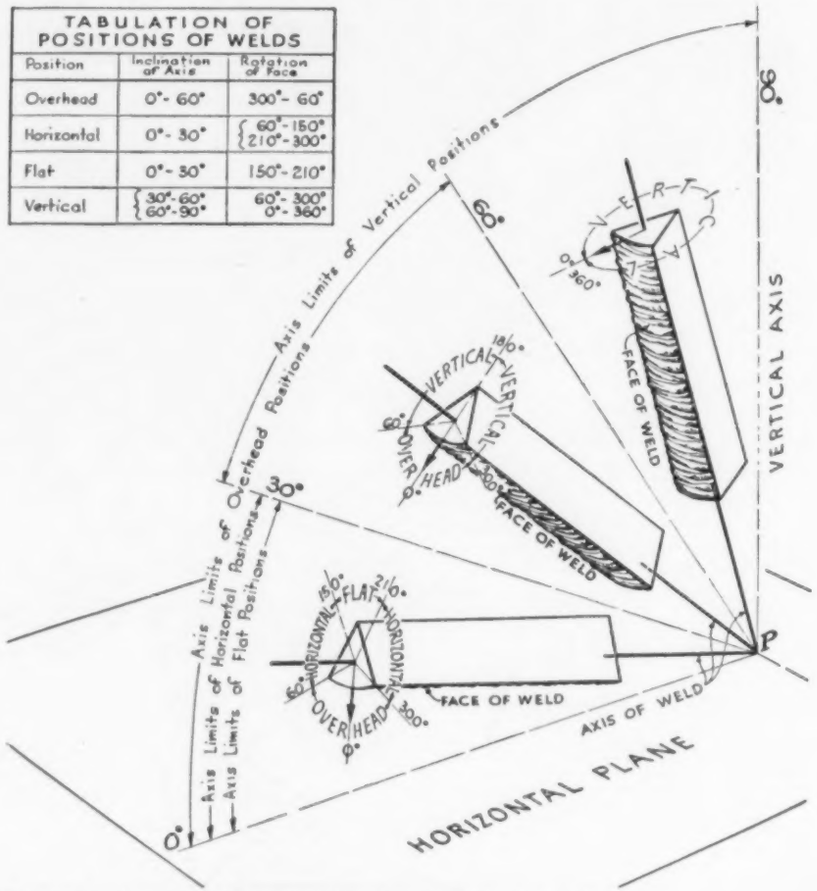
[4] 1939 Book of A.S.T.M. Standards, Part I.

plate shall be left on the asbestos until cold. The work shall be done at room temperature of not less than 65 F. and in the flat position. Weaving shall be the width of the groove up to four times the diameter of the core wire, when the layer shall be divided into two passes overlapping. Test plates shall preferably be so supported that warping due to welding will not cause the finished test plate to be out of line by more than 5 deg. If test plates become warped more than 5 deg. they shall be straightened cold before being stress-relieved when required.

(*d*) Two all-weld-metal tension specimens shall be machined from the finished test plate as shown in Fig. 1, and shall conform to the requirements for tensile strength and elongation prescribed in Table I.

(*e*) If either specimen fails, another

| TABULATION OF POSITIONS OF WELDS | | |
|---|---|---|
| Position | Inclination of Axis | Rotation of Face |
| Overhead | 0°- 60° | 300°- 60° |
| Horizontal | 0°- 30° | {60°-150° 210°-300°} |
| Flat | 0°- 30° | 150°- 210° |
| Vertical | {30°-60° 60°-90°} | {60°- 300° 0°- 360°} |

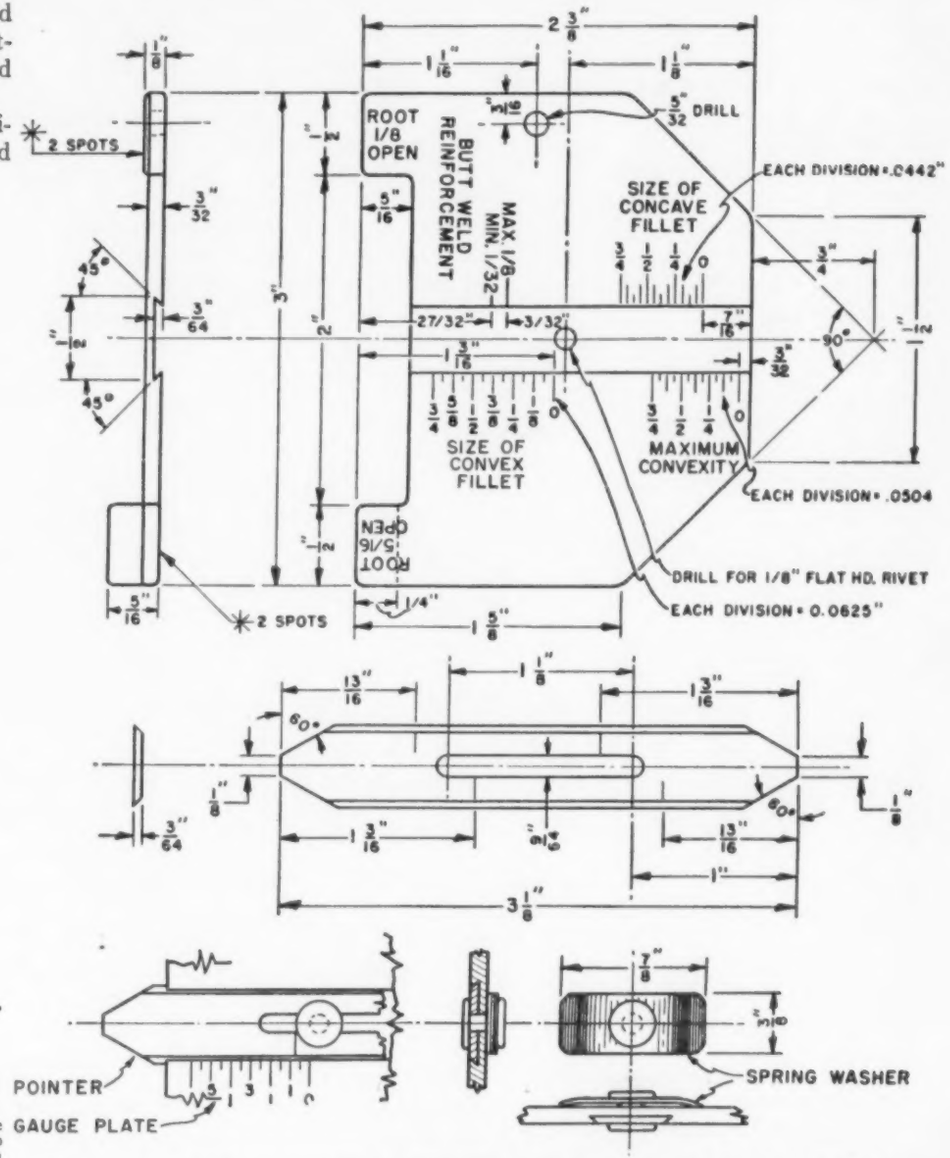



The horizontal reference plane is taken to lie always below the weld under consideration.
Inclination of axis is measured from the horizontal reference plane toward the vertical.
Angle of rotation of face is measured from a line perpendicular to the axis of the weld and lying in a vertical plane containing this axis. The reference position (0 deg.) of rotation of the face invariably points in the direction opposite to that in which the axis angle increases. The angle of rotation of the face of weld is measured in a clockwise direction from this reference position (0 deg.) when looking toward point "*P*".

FIG. 2.—Position of Welds.








NOTE 1.—All parts of this gage except washer shall be made of corrosion-resistant steel. Washer shall be made of blue spring steel, cadmium plated
NOTE 2.—Pointer shall be a "push fit" in gage plate and shall operate smoothly.
NOTE 3.—All lettering and graduations on gage shall be made by engraving.

FIG. 3.—Butt and Fillet Weld Gage.



test plate shall be welded and both speci-

(*g*) For each classification and size of

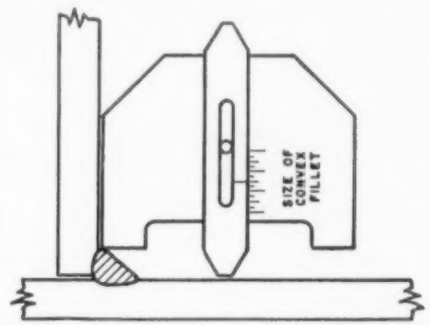
to welding will not cause the finished test plate to be out of line by more than

Table I.

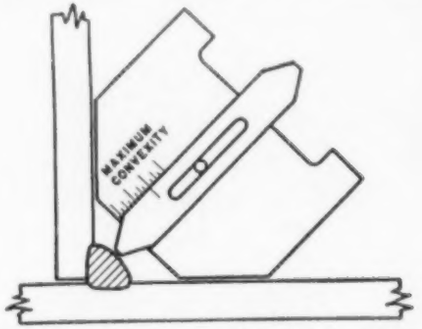
(*e*) If either specimen fails, another



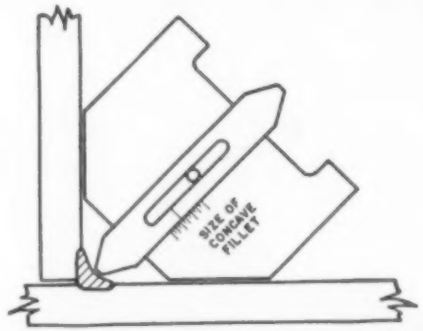
test plate shall be welded and both specimens shall conform to the requirements for tensile strength and elongation prescribed in Table I.



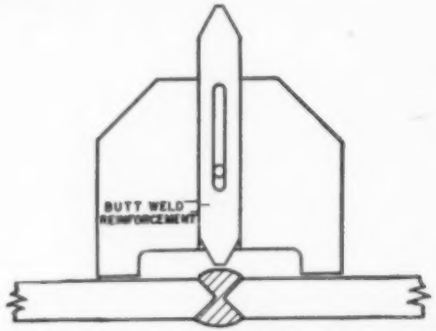

(*a*) To determine the size of a convex fillet weld, place gage against the toe of the shortest leg of the fillet and slide pointer out until it touches structure. Read "size of convex fillet" on face of gage. (See sketch above.)




(*c*) To determine the convexity of a convex fillet weld after its size has been determined, place gage against structure and slide pointer out until it touches the face of the fillet weld. The maximum convexity should not be greater than indicated by "maximum convexity" for the size of fillet being checked. (See sketch above.)




(*b*) To determine the size of a concave fillet weld, place gage against structure and slide pointer out until it touches the face of the fillet weld. Read "size of concave fillet," on face of gage. (See sketch above.)




(*d*) To determine the reinforcement of a butt weld, place gage so that reinforcement will come between legs of gage and slide pointer out until it touches the face of the weld. The permissible reinforcement is that indicated on the face of the gage. (See sketch above.)

FIG. 4.—Method of Using Butt and Fillet Weld Gage.

(*f*) Electrodes in each classification shall be capable of producing satisfactory welds which will conform to the all-weld-metal tension test requirements prescribed in Table I, for the type or types of current and the welding position or positions listed in the table. Welding positions shall be determined from Fig. 2.

(*g*) For each classification and size of electrode, specimens of welding shall be prepared with the type of current and the welding positions listed in Table I, and the height of the reinforcement on butt welds, and the size and concavity or convexity of fillet welds shall be measured with a gage similar to that shown in Fig. 3, in the manner illustrated in Fig. 4, and the results recorded. The results shall be furnished by the manufacturer to the purchaser upon request.

## CURRENT WELDING LITERATURE

(*Continued from page 501*)

described; attention given to machines used and operating variables encountered; welding data presented for different types of metals and alloys.

Iron Silicon Alloys. Survey of High Silicon Irons, B. N. Reavell. Chem. Age (May 4, 1940), vol. 42, no. 1088 (Met. section), pp. 19–20.

Machinery Manufacture. Welding as Substitute for Casting, S. F. Dorey. Shipbldg. & Shipg. Rec. (Feb. 22, 1940), vol. 55, no. 8, pp. 176–178; see also Foundry Trade J. (Feb. 29, 1940), vol. 62, no. 1228, pp. 173–175; Mar. Engr. (Apr. 1940), vol. 63, no. 753, pp. 91–95.

Machinery Manufacture. Welding as Substitute for Casting, S. F. Dorey. Shipbldr. & Mar. Engine-Bldr., vol. 47, no. 368 (Annual Int. No.), Apr. 1940, pp. 151–152.

Machinery Manufacture. Welding as Substitute for Casting, S. F. Dorey. Instn. Engrs. & Shipbldrs. in Scotland—Trans., vol. 83, pt. 5 (Mar. 1940), pp. 168–189, (discussion) pp. 189–196; (Apr. 1940), pt. 6, pp. 197–209.

Penstocks. Pinning Pipeline on Pikes Peak, E. L. Mosley. Eng. News-Rec. (Apr. 11, 1940), vol. 124, no. 15, pp. 88–90.

Petroleum Pipe Lines. Latest Methods and Equipment Used in Pipe-Line Reconditioning Work, F. H. Love. Petroleum Engr. (Apr. 1940), vol. 11, no. 7, pp. 81–83 and 86.

Pipe, Steel. Standard Specifications for Electric-Fusion-Welded Steel Pipe for High-Temperature and High-Pressure Service (A155–36). Am. Soc. Testing Mats. Standards, 1939, 8 pp. Approved as American Standard 836.11—1939 by Am. Standards Assn.

Shipbuilding Materials. Hi-Tensile Steel Ships, G. deRooy and P. Schoenmaker. Steel (Mar. 18, 1940), vol. 106, no. 12, pp. 56, 58 and 83; (Mar. 25), no. 13, pp. 68, 70–71 and 75. Investigation of welded high tensile steel structures show excellent fatigue resistance to combined dynamic and static stresses but reveals considerable sensitiveness to notch effects from rough weld surfaces; submarines of welded high tensile steel made by Dutch shipbuilders have 30% greater diving depths and other advantages; methods of construction and procedure are given.

Shipbuilding. Machine Flame Cutting, J. M. Heller, R. F. Helmkamp and A. H. Yoch. Mar. Eng. & Shipg. Rev. (May 1940), vol. 45, no. 5, pp. 78–92.

Soldering. Automatic Soldering, E. J. Stone. Steel (Apr. 22, 1940), vol. 106, no. 17, pp. 68–69.

Steam Heating Boilers. Welding of Heating Boilers, H. S. Card. Iron Age (Apr. 25, 1940), vol. 145, no. 17, pp. 42–43.

Welds. Strength of Fillet Welds, E. H. Eberhardt. Product Eng. (May 1940), vol. 11, no. 5, pp. 241–242. Charts for determining allowable transverse and longitudinal loads presented.

# Welding Society ACTIVITIES—Related Events

## A. W. S. NOMINATIONS FOR 1940

The AMERICAN WELDING SOCIETY Nominating Committee has selected the nominees listed below for the Officers for the forthcoming year. Nomination ballots must be received by the Secretary not later than July 1, 1940. No name (other than the Nominating Committee's candidates) is eligible to appear on the final voting ballot unless proposed by 25 qualified members.

For *President* (Term 1 year): G. F. Jenks.

For *First Vice-President* (Term 1 year): K. L. Hansen.

For *Second Vice-President* (Term 1 year): David Arnott.

For *Directors-at-Large* (Term 3 years): H. O. Hill, J. H. Deppeler, E. L. Mathy, A. G. Bissell.

For *District Vice-Presidents* (Term 1 year): New York and New England—P. J. Horgan. Middle Eastern—E. T. Scott. Middle Western—D. H. Corey. Southern—O. T. Barnett. Pacific Coast—L. W. Delhi.

## GEORGE T. HORTON, NEW CHAIRMAN OF PLAN GROUP

*(Taken from Chicago Sunday Tribune, June 16, 1940)*

George T. Horton, 4940 Woodlawn avenue, recently was named chairman of the Chicago Plan commission by Mayor Kelly. Mr. Horton, President of the AMERICAN WELDING SOCIETY, is the son of a bridge buider. He was born in Wisconsin and was graduated as a civil engineer from Rensselaer Polytechnic Institute, Troy, N. Y., of which he is a life trustee. He is a member of the American Society of Civil Engineers, American Society for Testing Materials and the Society of Naval Architects and Marine Engineers. Among his club affiliations are the University of Chicago, the South Shore and Flossmoor Country clubs and the Aero Club of Illinois. The plan commission consists of 14 citizen members and 12 public officials.

## PROPOSED CHANGES IN BY-LAWS

A ballot proposing changes in the By-Laws was sent out to the entire voting membership. These proposed amendments of the By-Laws provided for

(*a*) Establishment of Single Expiration Date for Payment of Membership Dues.

(*b*) Appointment of Committee on Permanent Funds.

(*c*) Change in Returns to Sections on Membership Dues.

In explanation of these proposed changes a letter was sent out by the Secretary, dated June 1st. The following paragraphs are reproduced from this letter.

"The purpose of proposed Amendment (*a*) is to simplify the clerical and accounting procedure at Headquarters and of the Sections, and to assist the Finance Committee in making its budget recommendations to the Board of Directors. The proposed plan for putting Amendment (*a*) into effect is as follows: On September 1st every member will be invoiced for a year's dues, and he will receive a monthly prorated credit against this total annual charge for the portion of dues for which he has already paid.

"Proposed Amendment (*b*) is to provide for the handling of reserve funds set aside on authorization of the Board of Directors.

"Proposed Amendment (*c*)—increasing the returns to Sections from 15 to 20% of the sum collected in dues during the calendar year, plus $100 each calendar year—is the result of a two years' study on the part of a special committee composed of Section Representatives and National Officers with a view to determining an equitable method of apportionment of dues. In this instance, because of the establishment of a single expiration date for payment of dues, it is planned to make payment to the Sections of the $100 at the beginning of each fiscal year rather than on the anniversary date as heretofore. The first year a monthly pro-rated deduction will be made against the $100 for the portion already paid to the Sections for the calendar year 1941."

## A. S. M. E. ANNUAL MEETING

Spokane, capitol of the industrial Northwest, has been selected as the place for the 1940 Fall Meeting of The American Society of Mechanical Engineers, to be held September 3rd to 6th, with headquarters at the Hotel Davenport. Arrangements for the meeting in the Washington city are practically complete. A group of papers, of interest to mechanical, civil, electrical and mining engineers, is to be presented in sessions sponsored by the Hydraulics, Wood Industries, Heat Transfer, Fuels, Power and Management Divisions of the Society. The inspection trips, stressing wood industries, power developments, mineral industries and scenic wonders, are unique and of general as well as of technical interest.

The program calls for technical sessions on Tuesday, Sept. 3rd, and Thursday, Sept. 5th, leaving Wednesday and Friday open for inspection trips. The trip to Grand Coulee Dam on Wednesday will be preceded by a general interest talk on the Dam at the banquet on Tuesday evening. Friday is being left open for trips to the lumber mill at Lewiston, the mines of northern Idaho, the Columbia River Basin Project or the scenic lakes of the region.

The meeting this fall will provide an excellent opportunity to visit the Grand Coulee Dam, the world's largest masonry structure. Visitors will be able to see the concrete placement work in its final stages and the installation of the hydraulic machinery. At the present time turbine parts are on the ground ready for assembly.

## A. S. M. E. NOMINEES

Nominations for 1941 officers of The American Society of Mechanical Engineers were announced today by Prof. O A. Leutweiler, chairman of the National Nominating Committee which has been holding sessions during the Semi-Annual Meeting of the Society in this city, June 17th to 20th. Election will be held by letter ballot of the entire membership of 15,000, closing on Sept. 24, 1940.

The nominees as presented by the Committee are:

*President*—William A. Hanley, in Charge of Engineering, Eli Lilly & Company, Indianapolis, Ind.

*Vice-Presidents*—Dean Samuel B. Earle, School of Engineering, Clemson Agricultural College, Clemson, S. C.; Frank H. Prouty, Partner, Prouty Bros. Engineering Co., Exchange Building, Denver, Colo.; Edwin B. Ricketts, Mechanical Engineer, Consolidated Edison Co. of New York, Inc., 4 Irving Place, New York, N. Y.

*Managers*—Prof. Huber O. Croft, Head of Mechanical Engineering Department, State University of Iowa, Iowa City, Iowa; Prof. Paul B. Eaton, Charge of Mechanical Engineering Department, Lafayette College, Easton, Pa.; George E. Hulse, Chief Engineer, Safety Car Heating & Lighting Co., New Haven, Conn.

# "IS IT FOR ME?"

You kind of hope it is — for a lot of good news and good times come your way by telephone.

Maybe it's a date for Sister Sue. Or a golf call for Dad. Or Bill asking if Jimmie can go to the movies. Or Grandma calling Mother to find out if things are all right.

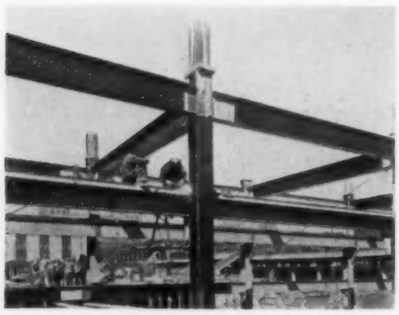
And everything is more likely to be all right when there's a telephone in the home. In many, many ways, it is a real friend of the family.

**BELL TELEPHONE SYSTEM**

*The Bell System cordially invites you to visit its exhibits at the New York World's Fair and the Golden Gate International Exposition, San Francisco.*

## NEW GENERAL ELECTRIC BUILDING

Welding is used extensively as the crane bay for the new General Electric building in Chicago begins to take shape. Brackets are shop welded to upright columns, crane girders welded to the top of the brackets, and still more brackets shop welded to the columns for the cross girders. These are all fillet welded. The steel rods



sticking out of the top of each column are also welded. They are joined to the steel slab plate on top of the column for the concrete column which will extend from the top of the crane bay to the next floor. The Strobel Construction Company of Chicago is doing the welding on the building with equipment sold by the Machinery and Welder Corporation, also of Chicago.

## CHICAGO BRIDGE AND IRON COMPANY CHANGES

We are advised the following changes have been made in the personnel of the sales department of the Chicago Bridge and Iron Company effective June 1, 1940.

S. C. Hamilton, District Sales Manager at Birmingham, is to be transferred to Houston, Tex.

R. A. Williams, who has been handling the sale of Morse filter plants, is to be transferred to Dallas, Tex., office.

H. F. Stearns is to be transferred from New York as District Sales Manager in charge of the Birmingham territory.

A. H. Heineman is to be transferred from New York to Birmingham sales department.

Herbert A. Guerin is to be transferred from Cleveland office to New York office.

George Jewett is to be transferred from Chicago to New York office. Mr. Jewett is now at Birmingham where he will spend several weeks' time studying some of the special work being done at that plant.

Ray Menefee has been transferred from Chicago engineering department to Cleveland office. Mr. Menefee reported in Cleveland May 1st.

William Fickett has been transferred from Chicago drafting room to the Chicago sales office, reporting on April 29th.

Kenneth Sandbach is being transferred from Hillside erection office to Philadelphia sales office.

## STEDMAN JOINS BASTIAN-BLESSING COMPANY

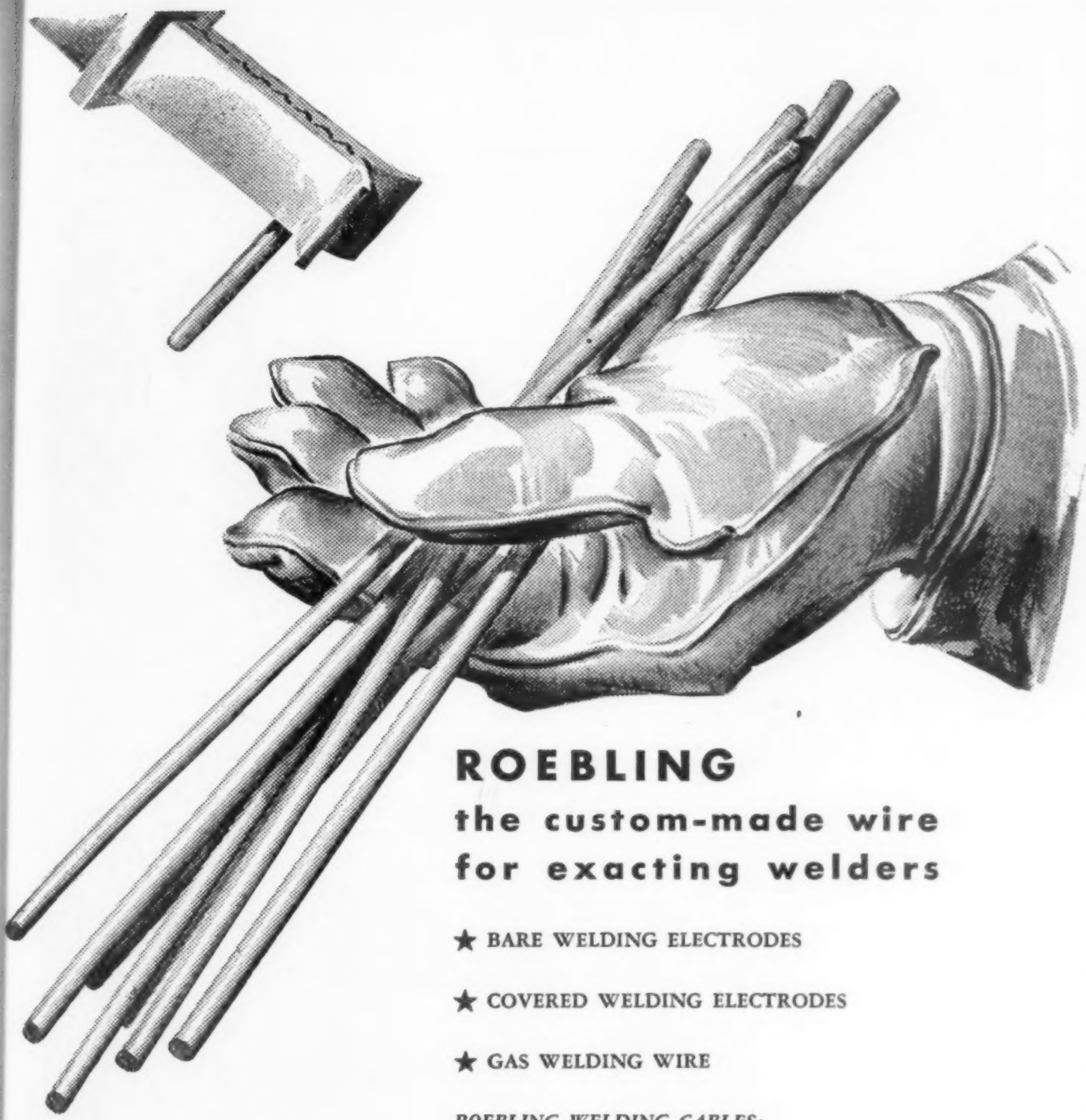
In announcing the appointment of Gerald E. Stedman as Sales Manager, Rego Division, Ellsworth L. Mills, Vice-

President in Charge of Sales of the Bastian-Blessing Company, manufacturing extensive lines of equipment in the gas welding, cutting, liquefied petroleum gas and soda fountain fields, revealed what may be a newer trend in industrial marketing.

"Stedman is nationally known in mer-

# INDEX TO ADVERTISERS


| | | | |
|---|---|---|---|
| Air Reduction Sales Co. | Outside back cover | Metal & Thermit Corporation | 544 |
| American Brass Company | 527 | National Carbide Corporation | 520 |
| American Telephone & Telegraph | 517 | National Metal Exposition | 541 |
| Anti-Borax Compound Company | 522 | Page Steel & Wire Division | Inside back cover |
| Bastian-Blessing Company | 522 | Resistance Welder Mfrs. Association | 521 |
| Chicago Bridge & Iron Company | 531 | John A. Roebling's Sons Company | 519 |
| Federal Machine & Welder Co. | 535 | Shawinigan Products Corp. | 526 |
| General Electric Co. | 532 & 533 | Stulz-Sickles Company | 526 |
| General Electric Co. | Inside front cover | Taylor-Winfield Corp. | 524 |
| Haynes Stellite Co. | 537 | Union Carbide and Carbon Corp. | 468 & 537 |
| Hobart Bros. | 465 | U. S. Steel Corp. Subsidiaries | 529 |
| Lenape Hydraulic Pressing & Forging Co. | 467 | Victor Equipment Company | 523 |
| The Linde Air Products Company | 468 | Westinghouse Electric & Mfg. Co. | 539 |
| P. R. Mallory & Co., Inc. | 522 | Wilson Welder & Metals Co., Inc. | 525 |



# ROEBLING

## the custom-made wire for exacting welders

★ BARE WELDING ELECTRODES

★ COVERED WELDING ELECTRODES

★ GAS WELDING WIRE

*ROEBLING WELDING CABLES:*

Made in a complete line of rubber and braided types for arc welding purposes.

JOHN A. ROEBLING'S SONS COMPANY, TRENTON, N.J.
*Branches in Principal Cities*

**ONLY A FINE PRODUCT MAY BEAR THE NAME ROEBLING**

chandising, research, sales training and public relations circles. He has directed the sales planning for many notable successes. A business writer for many trade publications, Stedman maintains national contact with more than 10,000 merchants and salesmen and is a strong exponent of basing sales programs on actual field experience."

## COMMUNICATION TO THE EDITOR

[*Editorial Note: The Society is not responsible for any statement made or opinion expressed in its publications.*]

I am writing to you on behalf of hundreds of young technical school graduates and apprentices like myself.

There seems to be a rumor and it has been written that there is an unnecessary lack of experienced mechanical and technical tradesmen at this time.

May I offer a suggestion for the solution to this problem? I am speaking particularly for welders as I have been looking for work in that field since completing a course in Electric Arc Welding a short time ago.

Perhaps, if the employers several years back would have given the apprentice of that day a chance there would be no shortage of experienced men at this time.

As a solution, I ask you, sir, why can't they give the new welding student a chance?

I believe you gentlemen of the AMERICAN WELDING SOCIETY can and will do something for the welding school graduate and thereby lessen the shortage of experienced men.

Respectfully yours,
SAMUEL SCHER

## OBITUARY

### Capt. E. P. Jessop

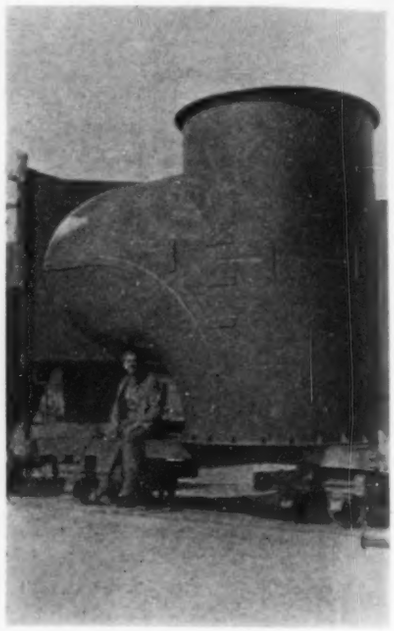
Captain Earl Percy Jessop, United States Navy, retired, a distinguished veteran of the World and Spanish-American Wars, a consulting engineer and the Federal Government nautical expert in the 1928 investigation here of the sinking of the liner Vestris, died on Wednesday in the United States Navy Hospital, Brooklyn, after an illness of more than six weeks. His age was 66. Burial with naval honors will take place in Arlington National Cemetery.

In 1916, and in the early part of this country's World War participation Captain Jessop was chief engineer of the New York Navy Yard in charge of repairs to German ships seized by the United States.

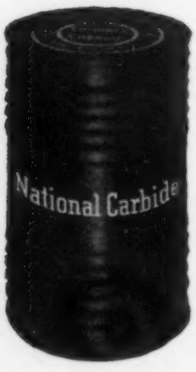
For "special meritorious service in devising method and applying electric welding to repairs of cast-iron parts of ex-German ships in the Port of New York by which months of time and millions of dollars were saved to the United States Government," Captain Jessop received the Distinguished Service Medal.

## PIPE TEE

From far off Queenstown, Tasmania, Mr. W. H. Beattie furnishes the illustration shown below. This photo shows a 6 ft. Diameter Pipe Tee for a furnace flue. The bands and straps on the pipe are supposed to supply an added factor of safety.



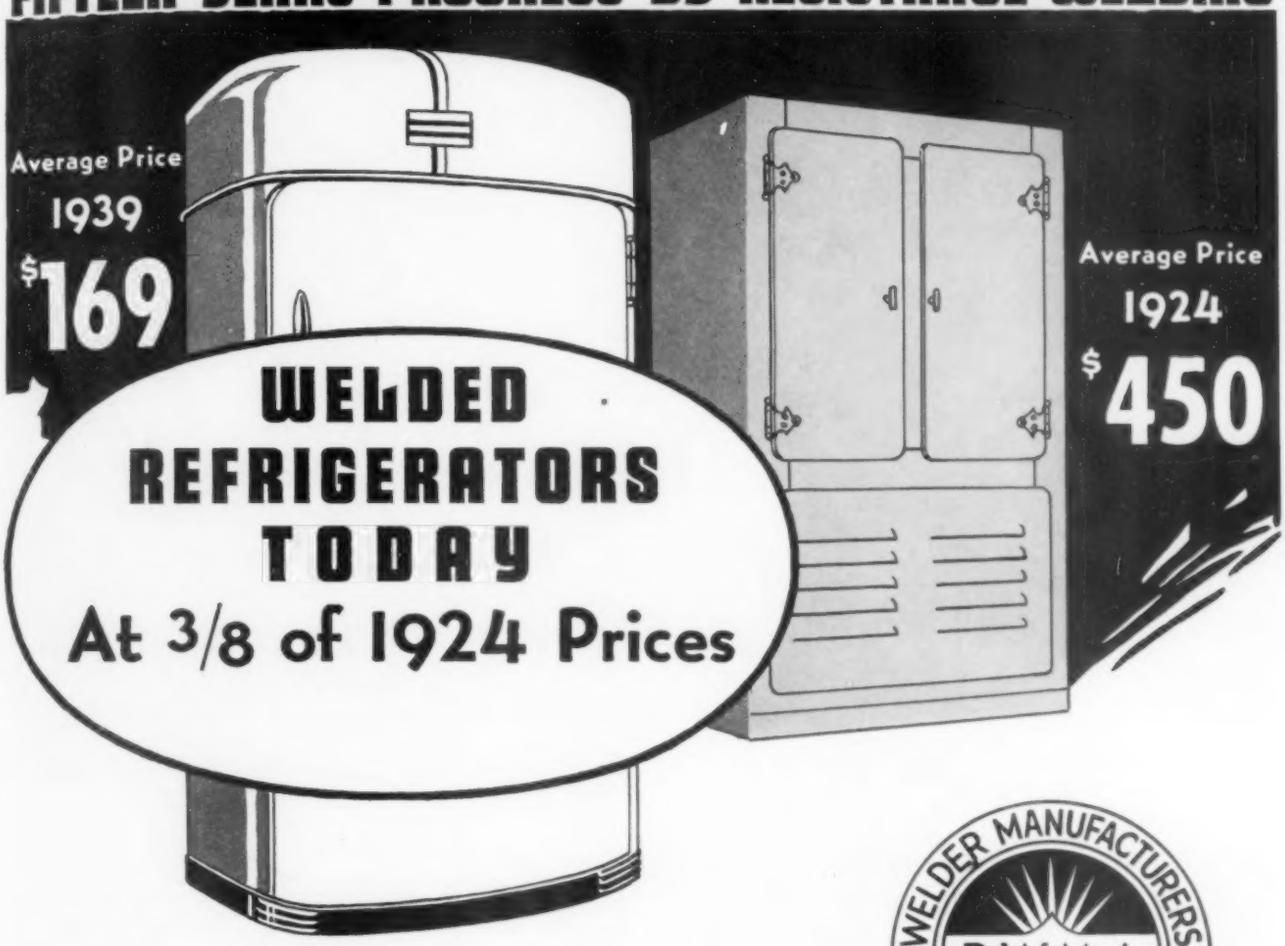

National
Carbide




DEPENDABLE
EFFICIENT
ECONOMICAL

FOR WELDING and CUTTING
Use National Carbide in the Red Drum
NATIONAL CARBIDE CORPORATION
Lincoln Building New York, N. Y.

# FIFTEEN YEARS PROGRESS BY RESISTANCE WELDING




● Resistance Welding has become, in the past fifteen years, an indispensable part of mass production methods in the electric refrigerator industry, responsible for price reductions of over 60%. Modern streamlined cabinets, compact, trouble-free compressors and evaporators, shelves, etc., are possible today because of resistance welding engineering achievements. No other known method of metal assembly could have accomplished such results in both economy and design.

Since resistance welding has made similar contributions in various other industries, replacing more expensive methods, perhaps it can do the same for you. Any of the member companies will be glad to consult with you on your particular problem.

# RESISTANCE WELDER

## MANUFACTURER'S ASSOCIATION

505 Arch Street Philadelphia, Pa.

RESISTANCE WELDER MANUFACTURERS ASSOCIATION • RWMA

## MEMBER COMPANIES

Acme Electric Welder Company, Los Angeles, Cal.
American Electric Fusion Corporation, Chicago, Ill.
Eisler Engineering Company, Newark, N. J.
Expert Welding Machine Co., Detroit, Mich.
Federal Machine and Welder Company, Warren, Ohio
Multi-Hydromatic Welding and Manufacturing Co., Detroit, Mich.
National Electric Welding Machines Co., Bay City, Mich.
Progressive Welder Company, Detroit, Mich.
Swift Electric Welder Company, Detroit, Mich.
Taylor-Hall Welding Corporation, Worcester, Mass.
Taylor-Winfield Corporation, Warren, Ohio
Thomson-Gibb Electric Welding Co., Lynn, Mass.
Welding Machines Mfg. Co., Detroit, Mich.

## ASSOCIATE MEMBER COMPANIES

P. R. Mallory and Co., Indianapolis, Ind.
S-M-S Corporation, Detroit, Mich.
Electroloy, Inc., New York City
Welding Sales and Engineering Co., Detroit, Mich.

## WELDED STEEL CARFLOATS FOR NEW YORK HARBOR

With 700 miles of waterfront and many rail terminal points, New York Harbor has for years been the scene of extensive transshipping operations involving the use of carfloats. In a single month as many as 76,099 freight cars involving 940,000 tons of miscellaneous freight have floated between various terminal points.

To augment its transshipping facilities in this busy harbor, the Long Island Railroad Company is placing in service four new welded steel carfloats, 330 feet by 40 feet by 11 feet. These are by far the largest welded carfloats that have been built up to the present time. Welded construction assures structural strength and makes possible faster building schedules. The four floats referred to were ordered from Dravo Corporation early last fall, and delivery has already begun.

The floats are framed transversely. Each has three massive longitudinal trusses, one on the center line and one on either side where wing sections attach to the deck and bottom plates. Each carfloat consists of two rake end compartments and twelve midbody compartments. All compartments are watertight. The shear strake plate is $1^1/_8$ inches thick; the bilge plate is $^1/_2$ inch and the deck plate $^3/_8$ inch.

One feature of these floats is the lack of fenders. It was felt that the use of fenders served to concentrate the forces from any blow, whereas the heavy $1^1/_8$-inch strake plate more easily distributed such forces.

The plate material was cut, fitted and welded into large pre-assemblies at Dravo's Neville Island shops, then shipped by rail some 300 miles to the Assembly Yard at Wilmington, Delaware. The floor members were welded to the bottom plate and the deck stringers were welded to the deck plates making shipping sections 8 feet wide by 22 feet 6 inches long.

Built-up trusses were fabricated in 24-foot lengths, the distance from bulkhead to bulkhead. Box wing sections were fabricated in 24-foot lengths. Integral with the wing section is the longitudinal truss component and the $1^1/_8$-inch shear

Fig. 1—Here the Bottom Plates Have Been Laid, the Center Truss Is Placed and the Bulkheads Erected. Whirler Crane Is Placing a 25-Foot Prefabricated Wing Section

Fig. 2—All Wing Sections Are in Place and the Greater Part of the Deck Has Been Laid. Work Now Starts on Forming the Rake Ends

Fig. 3—One of the Four Dravo-Built All-Welded Carfloats in Service in New York Harbor

Here's a holder that has won the plaudits of large spot welding users as a major advancement in the resistance welding field. It has been engineered with the utmost care and constructed of materials especially selected for high strength, high conductivity and resistance to wear.

One of the best-liked features of this Universal Off-Set Holder is the *Tip Knock-Out Device* which completely eliminates the difficulties often encountered in removing replaceable tapered shank tips.

Write today for complete specifications and prices.

**P. R. MALLORY & CO., INC.**
**INDIANAPOLIS INDIANA**
Cable Address—Pelmallo

P.R. MALLORY & CO. Inc.
MALLORY

**Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them**
**The Trade-Name is "ANTI-BORAX"**

*Ask for Them* *Unequalled for Quality*

**A Flux for every metal: Cast Iron Welding Flux No. 1.; Brazing Flux No. 2; Braz-Cast Flux No. 4, for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; "Anti-Borax" Tinning Compound No. 11.**

*Send for Free Samples*

**ANTI-BORAX COMPOUND COMPANY**
**Fort Wayne, Indiana**

**REGO**
**WELDING AND CUTTING EQUIPMENT**

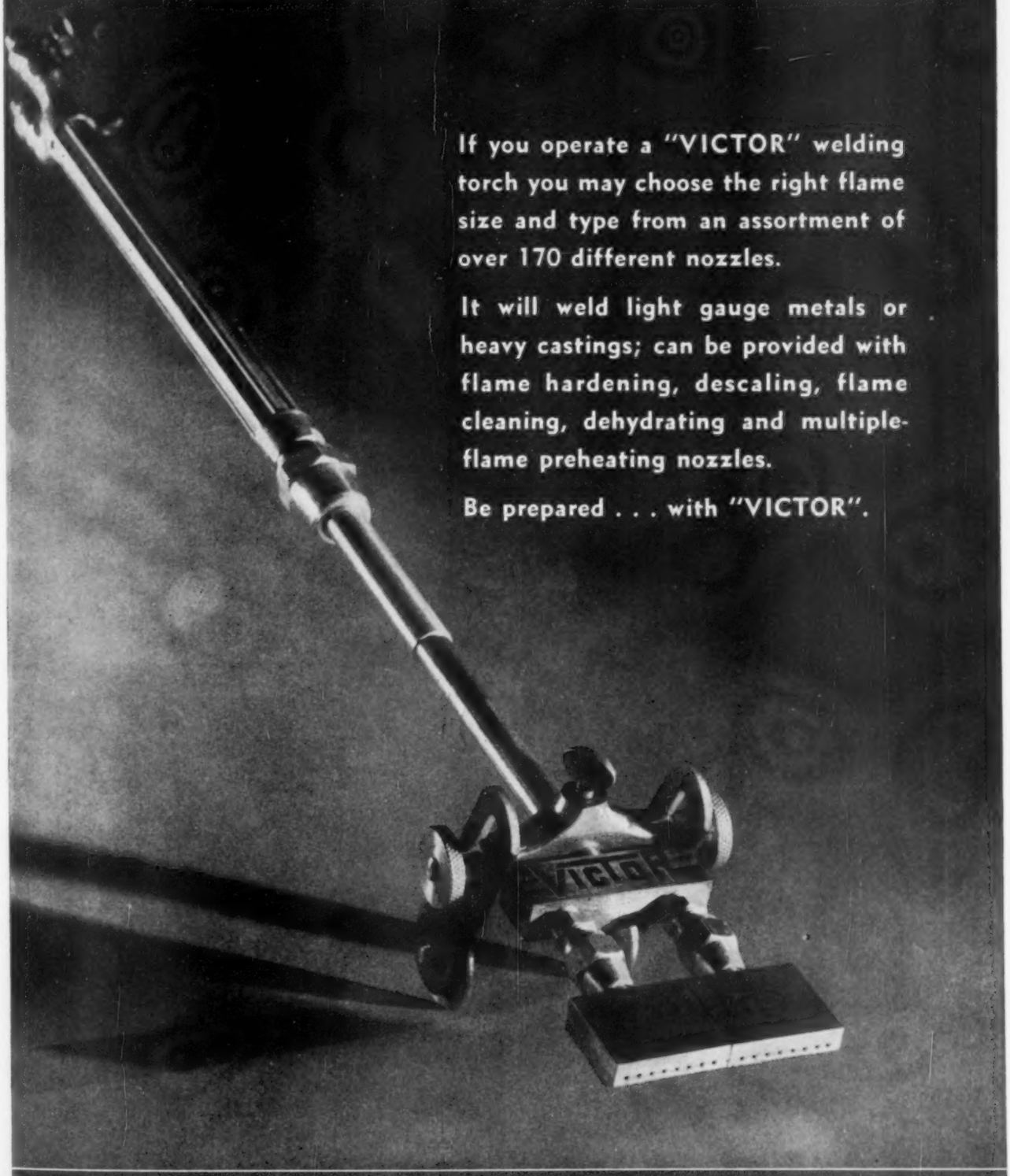
- Welding Torches
- Cutting Torches
- Economizers
- Regulators
- Outfits

FOR PLUS PROFIT SPECIFY REGO

Send for Catalog R-120 — with it you will have all the specifications you need for the buying of highest quality welding and cutting equipment.

The BASTIAN-BLESSING Company
282 E. ONTARIO CHICAGO

# CAN YOUR WELDING TORCH MEET ALL MODERN REQUIREMENTS?




If you operate a "VICTOR" welding torch you may choose the right flame size and type from an assortment of over 170 different nozzles.

It will weld light gauge metals or heavy castings; can be provided with flame hardening, descaling, flame cleaning, dehydrating and multiple-flame preheating nozzles.

Be prepared . . . with "VICTOR".

**VICTOR EQUIPMENT COMPANY**

EXECUTIVE OFFICES: 844-50 FOLSOM STREET, SAN FRANCISCO

DISTRIBUTING POINTS FROM COAST TO COAST

IN CANADA: HOLLUP CORP., LTD., 107 ATLANTIC AVENUE, TORONTO

strake plate. The weight of one of these sections is approximately 15 tons.

The order of assembly at Dravo's Wilmington Boat Yard is: (1) lay the bottom, (2) erect a 24-foot section of the center truss, (3) erect the bulkheads, (4) add the wing sections, (5) add the deck sections. Railroad tracks and fittings are installed and the float is ready for launching. Shop fabrication and yard assembly are done entirely by arc welding. The weight of a completed float is approximately 915 tons.

More than 30 years ago railroads began using steel construction to overcome obvious disadvantages inherent in the old-style wooden carfloats. In this way the use of steel for harbor-floating equipment was initiated. The excellent results in the form of increased unit size and reduced maintenance have been factors in influencing the use of steel for other harbor hulls.

## EVOLUTION OF ELECTRIC WASHING MACHINE SHOWS VALUE OF INDUSTRIAL PROGRESS

Thanks to industrial study and research, which has steadily improved design, produced new structural materials and advanced manufacturing operations, the 1940 housewife gets a better washing machine for $79.95 than the one her mother paid $155 for!

Today's electric washer, costing half as much, has higher capacity, easier and

safer operation, better appearance and lighter weight. Moreover, being $75 lower in price, it puts the social advantages of electric washing—time and labor saving—within reach of larger numbers of housewives.

*Economically* important is the fact that the greater markets, created for the electric washer by its lower price, developed an important industry, creating wealth and opportunities for employment for many workers.

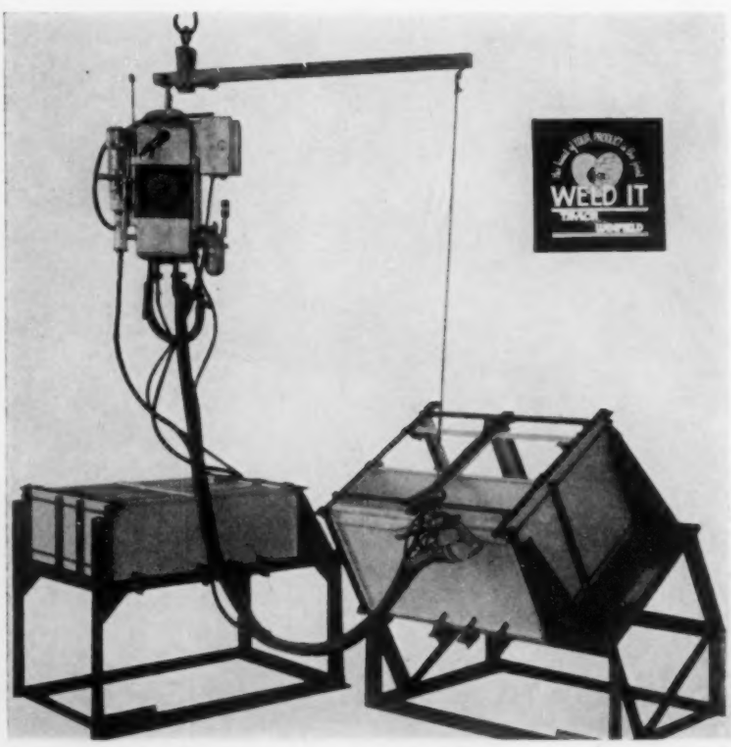
The accompanying photos, which show vividly the progressive evolution of the electric washer, were obtained from the Apex Electrical Mfg. Co. of Clevleand by The James F. Lincoln Arc Welding Foundation. The manufacturer reports "streamline design and lower cost was possible only through use of arc welding." The Foundation supplied the photos to attest the value of engineering study and research which it is stimulating by its $200,000 Industrial Progress Award Program. Four hundred fifty-eight awards, from $100 to $13,700, are offered for reports of industrial advances and improvements.

## AN INTERESTING PAMPHLET

A very interesting pamphlet of 24 pages has just been issued by The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, entitled "We Who Work at our Industrial Jobs." This pamphlet brings to the attention of the public a realization that the present plane of living is due to the "thinkers" and "doers" in industry. Copies of this pamphlet may be obtained from the Foundation.


*A New Line of* **PORTABLE WELDERS**

**STANDARDIZED AIR AND HYDRAULIC TYPES**




Supplemented by special designs to meet special applications. Portable welders should be used where the work is too bulky to move to stationary machines.

We are prepared to quote on your complete requirements including jigs and fixtures.

May we send bulletins or have a representative call?

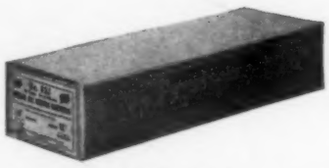
**TAYLOR-WINFIELD CORPORATION**

**1058 Mahoning Ave.**

**WARREN OHIO**

# DEMAND THE ELECTRODE THAT MEETS THE TEST!

Hartford
Appearance Weld



## WILSON NO. 851
(SHIELDED ARC)

***It's available at local distributors***

Pressure vessel welding requires high quality electrodes capable of meeting the rigid Hartford specifications — therefore specify Wilson #851 which meets the test *with plenty to spare*.

Wilson #851 is primarily recommended for "U" or "Vee" butt joints where welding is done in a flat position. It is also recommended for horizontal fillet welding. It can be used with exceptionally high currents to insure fastest possible welding speeds. Weld deposits have excellent physical properties which exceed those prescribed for Grade 10 by the A. W. S. filler metal specifications and meet the requirements of paragraphs U68 and U69 of the A. S. M. E. Code for Unfired Pressure Vessels. Spatter loss is low. The resultant slag prevents oxidation of the newly deposited metal, yet is practically self-removing after the weld has cooled.

You can obtain from your local dealer a supply of Wilson #851 and all other Wilson Electrodes — there's one for every arc welding need. Write for your copy of the new Wilson Electrode Catalog. Copy will be sent upon request.

**WILSON WELDER and METALS CO., INC.**

***General Offices: 60 East 42nd Street, New York, N. Y.***

### SWISS ACETYLENE SOCIETY

The Annual Meeting of the Swiss Acetylene Society was scheduled to be held in Bienne on May 25th. Besides an afternoon lecture on "Welding Problems" by Professor M. Roš, who has been with the Swiss Federal Materials Laboratory for the past 15 years, the Annual Report of the Society for 1939 was to have been presented. The Society issues its well-known monthly magazine, *Journal de la Soudure*, conducts courses of welding instruction and, in its new building in Basel, serves as a center of technical information on welding. The welding and cutting exhibition at the Zurich Exposition was under the Society's direction. The Society had 820 members at the end of 1939.

### PURCHASING AGENT

Mr. C. R. Hale has been appointed purchasing agent of the Air Reduction Sales Company, 60 East 42nd Street, New York,

N. Y., and its subsidiary and affiliated companies. Mr. Hale, a Columbia graduate, joined the purchasing department of Airco in 1925 and has been assistant purchasing agent since 1936. In his new position Mr. Hale succeeds H. M. Daggett, who has retired.

### E. H. ANCHORS

E. H. Anchors, formerly branch manager for the Air Reduction Sales Company at Atlanta, Ga., has been appointed manager of the Oklahoma City District.

Mr. Anchors began his career 15 years ago with the Commercial Acetylene Supply Company. He was southern manager of this company when it was acquired by Air Reduction. Since that time he has served continuously as branch manager at Atlanta.

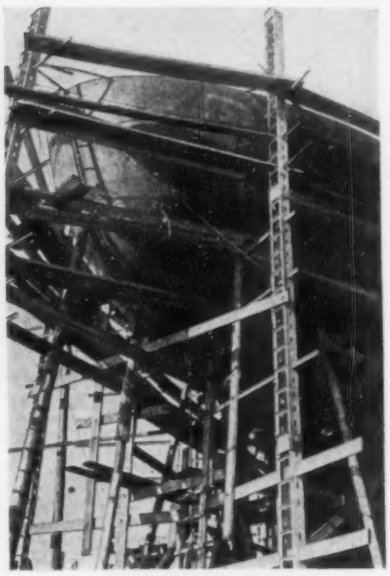
### METAL SPRAYING

A new 16-page booklet on the metallizing process, giving information on the new MOGUL Model "P" and "S" metallizing gun, together with a 24-page booklet on various metallizing applications, is now available for distribution. This includes a complete history on the aluminizing process which has been used extensively for a number of years to combat oxidation from high temperatures.

These booklets may be obtained by addressing The Metallizing Company of America, Inc., 562 West Washington Blvd., Chicago, Ill.

### S. S. EXCHEQUER

The S. S. Exchequer was launched by The Ingalls Shipbuilding Corporation at their Pascagoula, Mississippi plant on Saturday, June 8th. This is a hundred per cent all-welded vessel, the largest of its type (17,600 ton) built to fly the American flag. Close-up view of the stern showing welded plates in position is indicated below.



### BRAZING ALLOYS LEAFLET

A very interesting four-page leaflet on "Silver Soldering and Brazing" has been prepared by Handy & Harman, 82 Fulton Street, New York. Copies may be obtained on request.


SHAWINIGAN CARBIDE

For OXY-ACETYLENE WELDING AND CUTTING OF METALS

SHAWINIGAN PRODUCTS CORPORATION
EMPIRE STATE BUILDING
NEW YORK, N.Y.

*SAVE MONEY . . . BY WELDING*

Jaw Plates, Gyratory and Roll Crushers, Shovel Teeth, Hammers, Tractor Tread Grousers

with

MANGANAL

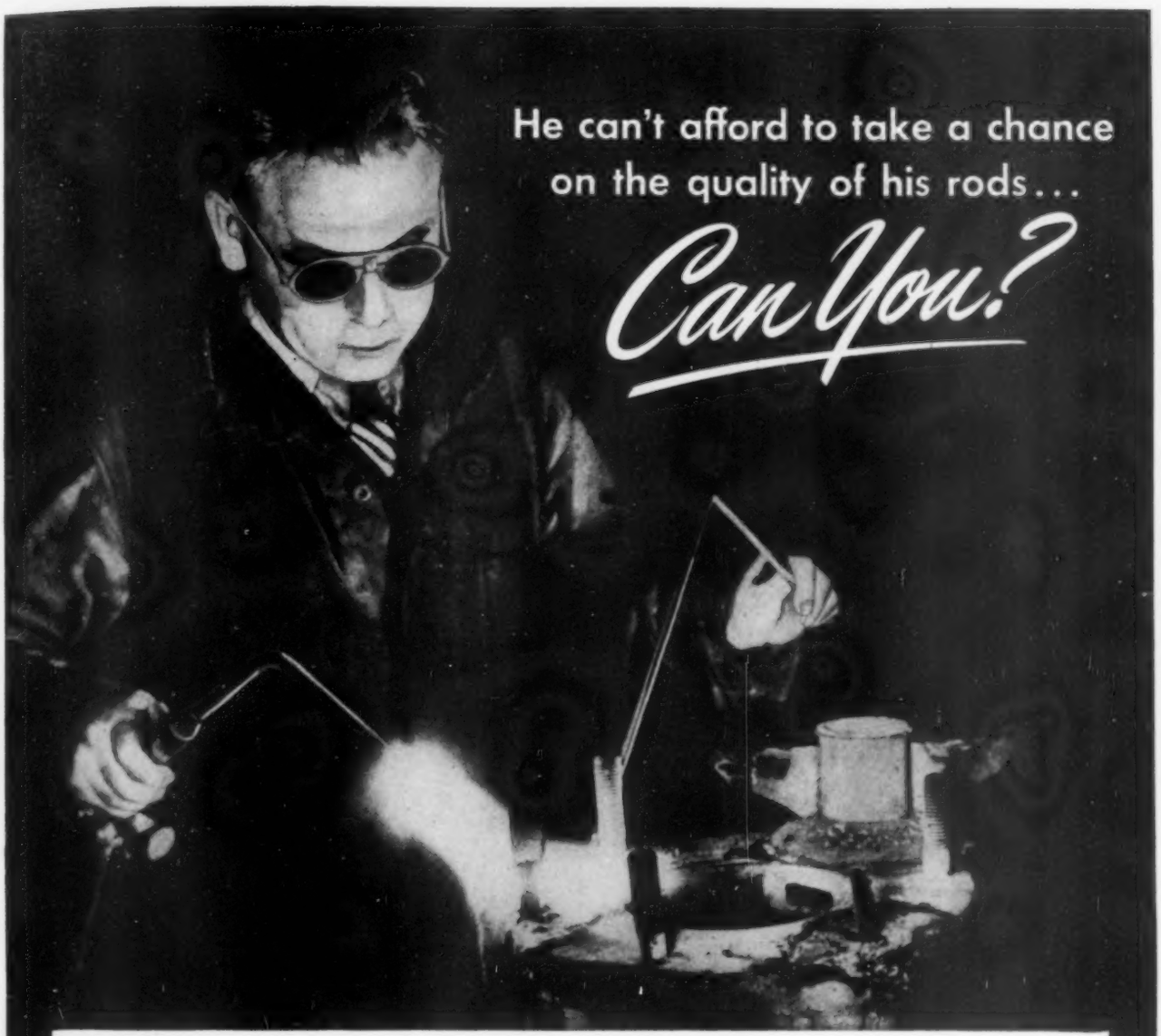
Reg. U. S. Pat. Office. U. S. Patents 1,876,738—1,947,167—2,021,945

*11 to 13% Manganese Nickel Steel*

WELDING ELECTRODES, WEDGE and APPLICATOR BARS, HOT ROLLED PLATES

STULZ-SICKELS CO *Sole Producers* 134-142 Lafayette St., Newark, N. J.

*Sold Thru Distributors Only*




EVERY metallurgical precaution is taken to assure the uniform composition and unvarying high quality of Anaconda Welding Rods.

Thousands of foremen, welders and helpers prefer them to all other brands. They help good workmen do good work.

There are eighteen different Anaconda Welding Rods... a suitable one for every gas or electric bronze-welding purpose. Available through leading distributors. Usually shipped in bulk, but also obtainable in clearly labeled 10-lb. packages. Our new publication B-13, mailed on request. 40121

• • •

*Visit the Copper & Brass Industry Exhibit in the Hall of Industry, New York World's Fair, 1940*

ANACONDA
from mine to consumer

# Anaconda Welding Rods

THE AMERICAN BRASS COMPANY, General Offices: Waterbury, Connecticut

*In Canada: Anaconda American Brass Ltd., New Toronto, Ont. • Subsidiary of Anaconda Copper Mining Company*

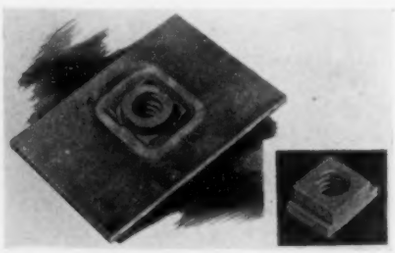
# NEW PRODUCTS

**The Society assumes no responsibility for the validity of claims in this Section**

### INCREASING THREAD AREA IN SHEET METAL

FAST-ON lock nuts provide a new method of increasing the thread area in sheet metal, making practical the use of lighter gage metals and simplifying assembly in inaccessible places.

Punched out of a drawn flanged section—it is sheared and the hole is located in a one-stroke operation. And it only has to be tapped to complete its manufacture.

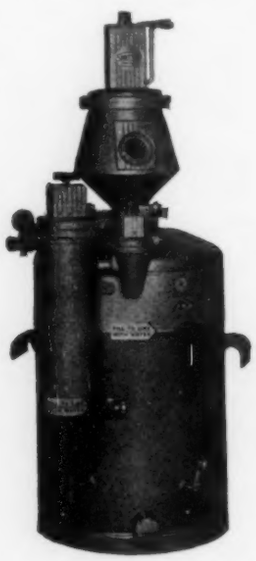


The small (square) portion of the nut is inserted in the square hole that has been previously cut in the metal, protruding just enough for the four corners to be clinched (positively locked) with a swaging tool. As contrasted to riveting, this locking of the FAST-ON nut into position is a positive action, it will not work loose and any variation in the thickness of the metal is automatically taken care of. The thread runs to the very edge of the nut, as compared to other clinch nuts, which makes practical its use with shorter screws and closer clearances. FabriSteel Products, Inc., Kerr Machinery Bldg., Detroit, Mich.

### ACETYLENE GENERATOR

Perfect regulation of outlet pressures, cooler, cleaner gas and complete elimination of the "hot belt" are features of a new line of two-stage portable acetylene generators announced by Smith Welding Equipment Corporation. These are known as type "J" and are listed by Underwriters' Laboratories, Inc., and Factory Mutual Fire Insurance Companies.

All water in the generator chamber is circulated by a non-mechanical, air-lift device which simultaneously cools and scrubs the newly generated acetylene gas. This completely automatic circulation of the water within the generator results in the elimination of the customary hot belt at the water line.



The size 14 *ND* carbide is fed into the water as needed by a large pressure-regulating, diaphragm-type feeding mechanism. Generated acetylene passes through the water-circulating device through the hydraulic back-pressure valve and filter tank. Here it passes through another pressure regulator which may be set at the desired outlet pressure.

Simplicity of operation and portability are features in these generators which are available in 15, 30 and 50-pound sizes.

Write to Smith Welding Equipment Corporation, Minneapolis, Minnesota, for further information.

### INTERESTING TORCHES FOR SPECIAL PURPOSES

The welding torch possesses a versatility far beyond its generally accredited utility to weld, braze, solder, hard surface and heat.

The three torches here illustrated offer an interesting example of the virtually unlimited scope of torch flame application. Figure 1, for instance, shows a torch which was specially designed to flame-harden the surfaces of rock plant screening plates. The wide roller facilitates the torch operation and prevents tilting of the nozzle as

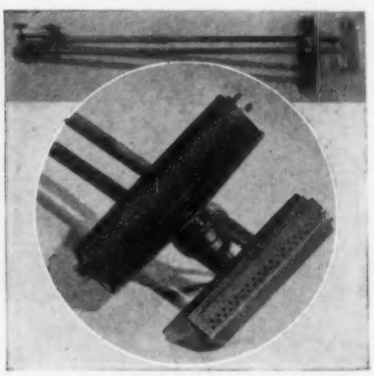


Fig. 1


**All About Arc Welding**

**THE NEW HANDBOOK**

**YOUR GUIDE TO PROGRESS**

★ The new 6th edition "Procedure Handbook of Arc Welding Design and Practice" contains up-to-date facts about all aspects of arc welding and its many profitable applications. Will enable you to keep abreast of this fast-growing industry for personal advancement and profit.

★ ★ ★

Complete in every detail. In eight parts—(1) Welding Methods and Equipment. (2) Technique of Welding. (3) Procedures, Speeds and Costs. (4) Weld Metal and Methods of Testing. (5) Weldability of Metals. (6) Machine Design. (7) Structural Design. (8) Actual Applications.

Recognized throughout the world as the authentic reference book on arc welding. More than 90,000 copies of first five editions have been sold. 6th edition is an entirely NEW Handbook, containing important new information. Written clearly. Well indexed for quick reference. Size 6" x 9" x 1⅝" —ideal for use in office, shop or school. Printed on fine paper. Bound in semi-flexible simulated leather—gold embossed.

Order your copy today. Mail your order and check to

AMERICAN WELDING SOCIETY

33 West 39th Street New York City

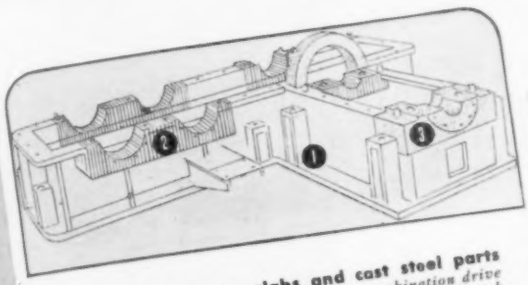
**NET ADVERTISING RATES**

**Black and White** **Effective May 1938**

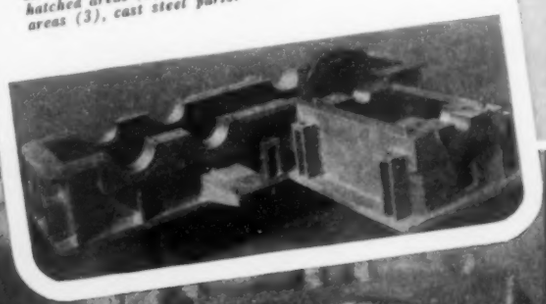
| Space | One Insertion | Three Insertions | Six Insertions | Twelve Insertions |
|---|---|---|---|---|
| *Full Page | $100 | $90 | $80 | $70 |
| Half Page | 60 | 50 | 45 | 40 |
| Quarter Page | 35 | 30 | 27 | 25 |
| Eighth Page | 25 | 20 | 17 | 15 |
| *Inside Preferred | 115 | 105 | 95 | 85 |

*10% Extra for bleed full pages. Color $40 extra per color added.

# "Welding rolled steel
## offers a lot more advantages than we thought"

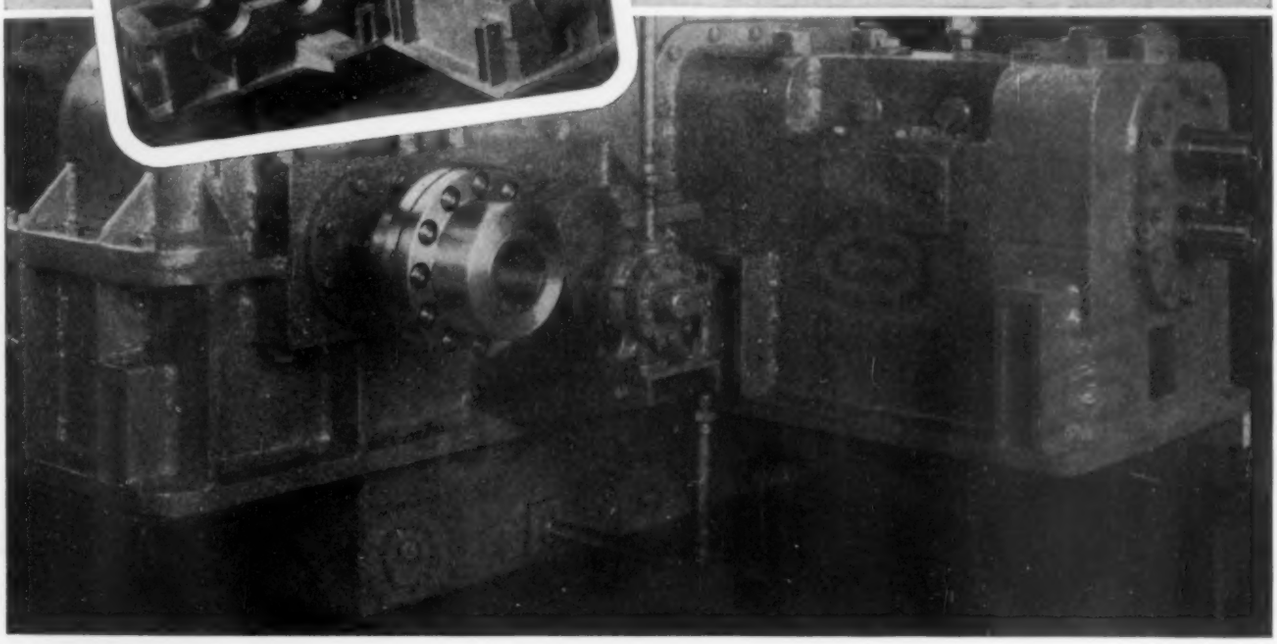



**Rolled steel plates, slabs and cast steel parts** *are effectively combined in this heavy combination drive unit. Inset shows lower half of this assembly. Sketch shows in white (1), parts fabricated from plates; in hatched areas (2), parts flame-cut from slabs; in dotted areas (3), cast steel parts.*



***For lighter, stronger, longer-wearing equipment fabricate it by welding with these better steels:***

**U·S·S Cor-Ten**—to resist corrosion, to reduce weight or increase strength.
**U·S·S Man-Ten** — to increase strength without adding weight.
**U·S·S Abrasion Resisting Steel**— for use where abrasive conditions are exceptionally severe.
**U·S·S Heat Resisting Steel**—to combat high temperatures.
**U·S·S Stainless Steel**—to resist corrosion of all kinds.
**U·S·S Carilloy Alloy Steels**–to carry tremendous bearing pressures.



"OF course we have been using rolled steel right along in machine construction. It saves time and money. But the modern special steels now available, together with the improvements in welding and flame-cutting practices, have opened up possibilities we never thought of before.

"Now we can design equipment with its true functional requirements in mind—every part can be made to perform at fullest efficiency. And our machines not only function better, but are better looking and generally cost less to fabricate."

Designers and fabricators everywhere are saying just that. They are realizing that welded, rolled steel construction permits them to use the entire range of metallurgy's special steels—combined with one another, or with plain steels or castings, to improve their product and reduce its cost.

Are you taking full advantage of the special steels now available? It will pay you to consult a U·S·S engineer on the best ways to use them. He will be glad to help you.

*This symbol represents the highest quality, the finest metallurgical service.*

USS

**CARNEGIE-ILLINOIS STEEL CORPORATION,** *Pittsburgh and Chicago*
**COLUMBIA STEEL COMPANY,** *San Francisco*
**TENNESSEE COAL, IRON & RAILROAD COMPANY,** *Birmingham*
United States Steel Export Company, New York

**UNITED STATES STEEL**

Fig. 2

it passes over the series of holes in the plate.

Innumerable flame-hardening nozzle sizes and types are required to cover the wide range of the flame-hardening and flame-softening processes. Figure 2 illustrates a large, circular, multiple-flame heating nozzle designed primarily to take out buckles in plates by the application of heat. This particular torch type, as here illustrated, has a water-cooled tip and can be provided with integral quenching head.

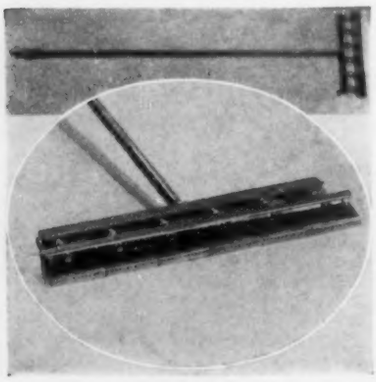


Fig. 3

Figure 3 illustrates one of several types of flame-dehydrating and -descaling nozzles. Flame descaling and dehydrating, while by no means new, are processes now more and more widely employed to remove rust or occluded moisture from structural steel surfaces prior to painting them. The nozzle here shown is comprised of removable sections permitting the width of the ribbon of flames to be adjusted to meet specific requirements.

All of these and many similar types of nozzles are manufactured by Victor Equipment Company of San Francisco and each of them is designed to fit onto the standard Victor welding torch butt.

## ELECTRIC WELDERS RUN ON NATURAL GAS

Among the first gasoline-engine-driven welding sets running on natural gas to be operated in the South are those being used by the United Gas Pipe Line Company of Shreveport to erect a new gasoline plant at a site near Lake Bistineau, Louisiana. The machines are averaging approximately 2000 cubic feet of natural gas consumption per machine per day; the gasoline consumption for this same work would average approximately 20 gallons per machine per day. Ensign natural-gas carburetors have been installed on these machines. The machines are standard 300-ampere, gas-engine-driven, arc welding sets, which were converted for natural gas consumption and furnished on the job by the Hughes Welding Supply Company, Shreveport, General Electric arc-welding distributor.

## FACE SHIELD

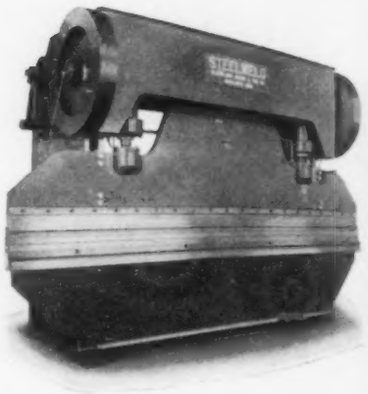
A new B & C face shield with a plastacele window that slides in and out of a fiber frame, making replacement practical at a fraction of the cost is announced by The Boyer & Campbell Company, Detroit.

Besides simplifying replacement the fiber frame affords considerably more face protection than the conventional metal bound type.

Five features are: (1) The New Fiber Frame with replaceable plastacele window, which is ideally adapted to spot, flash, and gun welding, buffing, polishing, wire brushing, etc.; (2) A 24-Mesh Monel Screen Window recommended for babbitting, heat protection, heavy scale, band sawyers, etc.; (3) Fiber Front and Glass Holder that gives complete protection for acetylene welding, burning, scarfing, etc.; (4) Fiber Crown and Rubber Apron, which gives broad protection for acid workers; (5) The Conventional type of metal bound plastacele window.

## BENDING PRESS

The Steelweld Machinery Division of The Cleveland Crane & Engineering Company, Wickliffe, Ohio, announces the development of a series of Steelweld bending presses adaptable for extensions of bed and ram at one or both ends.



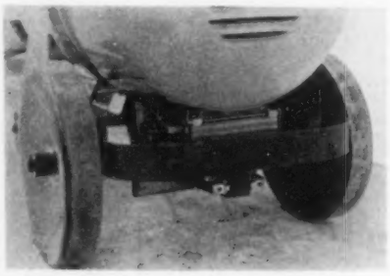
Illustrated is a Steelweld model H-8 recently completed for a Stockholm, Sweden, company, provided with extensions of 2 ft. 0 in. on each end. This press normally handles plate 8 ft. 0 in. x $^5/_{16}$ in. between housings, but the extensions make possible the forming of plate 14 ft. 0 in. x No. 12 gage.

The frames for these machines are of the one-piece all-welded construction and will remain rigid for life.

## AUTOMATIC START AND STOP DEVICE FOR ARC WELDERS

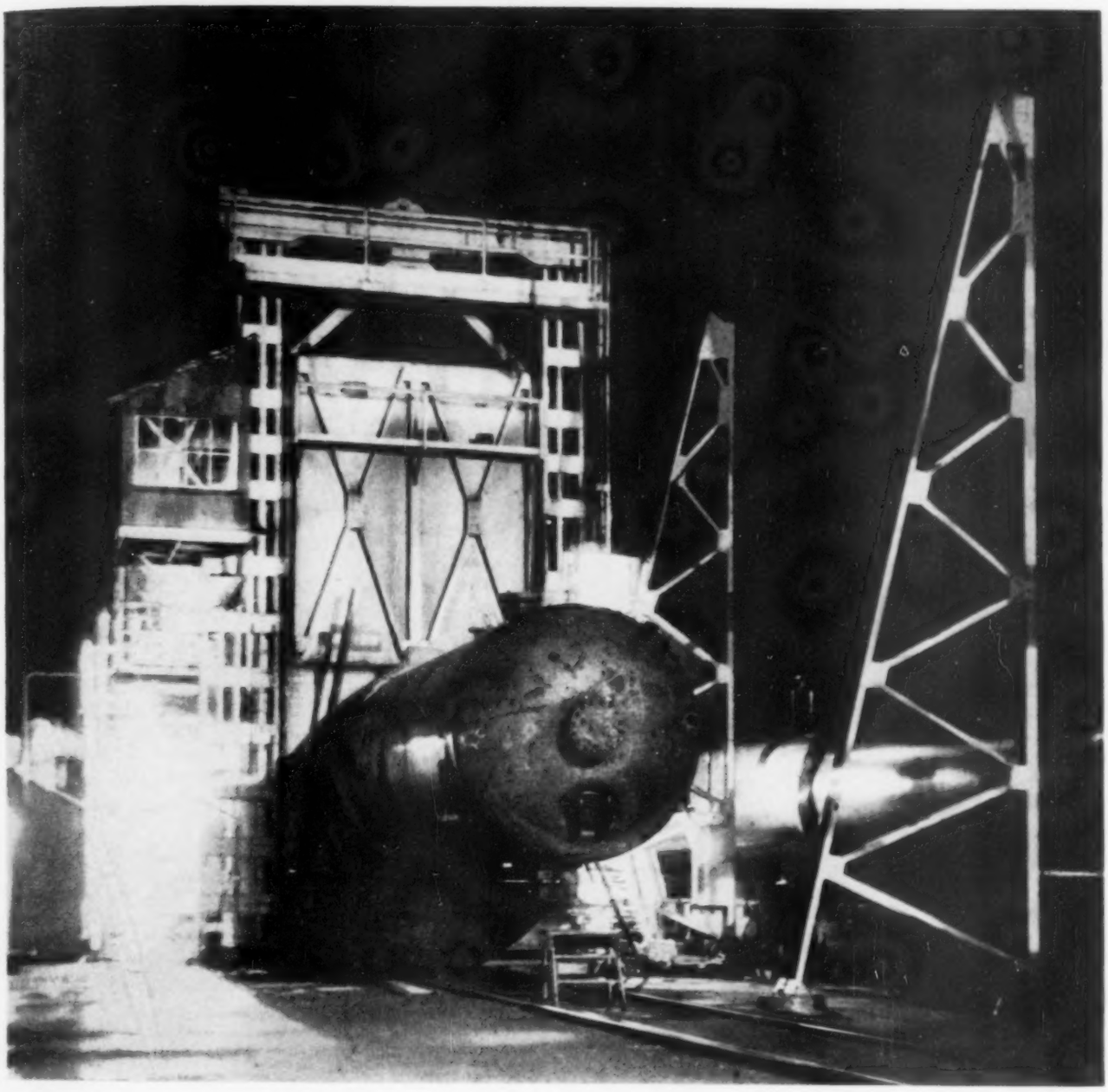
In an effort to eliminate the waste incurred from frequent idling of an arc welder between jobs, the Wilson Welder and Metals Co., Inc., New York, has announced a new automatic start and stop device. It is for use on any magnetic starter, motor generator arc welder, such as the Wilson "Hornet," which is driven by an A.C. motor.

With this Wilson device, the operator starts the welding unit simply by touching the work with his electrode holder. As long as he is welding, the unit keeps running; when welding is interrupted, the machine automatically stops after a time delay which may be set between $^1/_2$ to $1^1/_2$ minutes, to suit the conditions



of particular job at hand. The time delay prevents undesirable frequent stoppings in case of a tacking job.

The standard device is reconnectable for 220 or 440 volts, or it may be supplied for other A.C. voltages (60 cycles only). It is easily installed either on or near the machine. Further information about the new automatic start and stop device may be obtained by writing Wilson Welder and Metals Co., Inc., 60 East 42nd Street, New York, N. Y.



# PRESSURE VESSELS

## . . . . of welded construction

This night view shows a long pressure vessel being stress-relieved at our Birmingham plant. Complete shop welding of vessels of this type can be done where the size will permit shipment. The stress-relieving furnace will take tanks up to 14 ft. in diameter but shipping facilities usually are the limiting factor. In addition to up-to-date welding and stress-relieving facilities this plant has X-ray equipment for use on welded seams.

## CHICAGO BRIDGE & IRON COMPANY

| | | | | | |
|---|---|---|---|---|---|
| Chicago | 2455 Old Colony Bldg. | Birmingham | 1507 North 50th Street | Philadelphia | 1668-1700 Walnut St. Bldg. |
| New York | 3398-165 Broadway Bldg. | Tulsa | 1654 Hunt Bldg. | Boston | 1565 Consolidated Gas Bldg. |
| Cleveland | 2282 Rockefeller Bldg. | Houston | 2919 Main Street | San Francisco | 1097 Rialto Bldg. |
| Dallas | 1489 Liberty Bank Bldg. | Detroit | 1556 Lafayette Bldg. | Los Angeles | 1455 Wm. Fox Bldg. |

*Fabricating plants in CHICAGO, BIRMINGHAM, and GREENVILLE, PA.*

# WHY THE TRADE'S

## HERE'S A WELDER....

### For BIG-WELDER WORK CAPACITY and small-welder investment and operating cost

### With QUALITY in both features and design—built to specifications that assure you

## PROFITABLE PERFORMANCE

AND HERE are just a few of the features that make this NEW welder the pace-maker in value and performance . . .

**Instant Recovery Voltage Always Exceeds Arc Voltage** on any type of joint, with any electrode, at any heat . . . prevents time-wasting arc pop-outs under all conditions . . . keeps arc working.

**Adequate Limitation of Current Peaks** prevents excessive spatter . . . saves electrodes and operator's time.

**Isothermic Overload Protection** safeguards motor against injury . . . never interrupts service unnecessarily.

**Self-excitation** avoids maintenance and upkeep of an extra generating unit.

**Quick, Easy Adjustment of Welding Current** obtained by a four-point tap switch (for speed), and a field rheostat (for accuracy). A large, easily read scale indicates welding current.

**Horizontal Mounting** permits bearings to operate without excessive end thrust, and assures efficient lubrication.

**Self-sealed Ball Bearings** of the latest approved design that keeps grease in and dirt out. In ordinary service, they may operate as long as three years without regreasing.

**Power Saving**—Full range of current adjustment is obtained without the use of a current-limiting resistor, thus saving 10 to 15 per cent of power cost.

The split-pole, cross-field design of this new welder has long been used with outstanding success for the entire direct-current line of G-E arc welders. Supplied with or without ball-bearing running gear. Also available for V-belt drive for those who wish to build their own gas-engine drive.

Horizontal, ball-bearing, drip-proof construction. With motor drive, occupies less than $2\frac{3}{4}$ sq ft of floor area and weighs less than 395 lb. Dynamically balanced, especially smooth and quiet in operation, and commutation is excellent.

### *For Manufacturers*

Big enough for the large majority of jobs—yet economical on light work—this new welder is ideally suited to the demands that bring steady profit. Why not cash in on these new earnings with this new G-E 200-amp arc welder—designed to give you modern arc welding at its best?

### *For Job Shops*

Many manufacturers are adopting low-priced welders for light work to gain savings in over-all welding costs and to release larger machines for heavier production work.

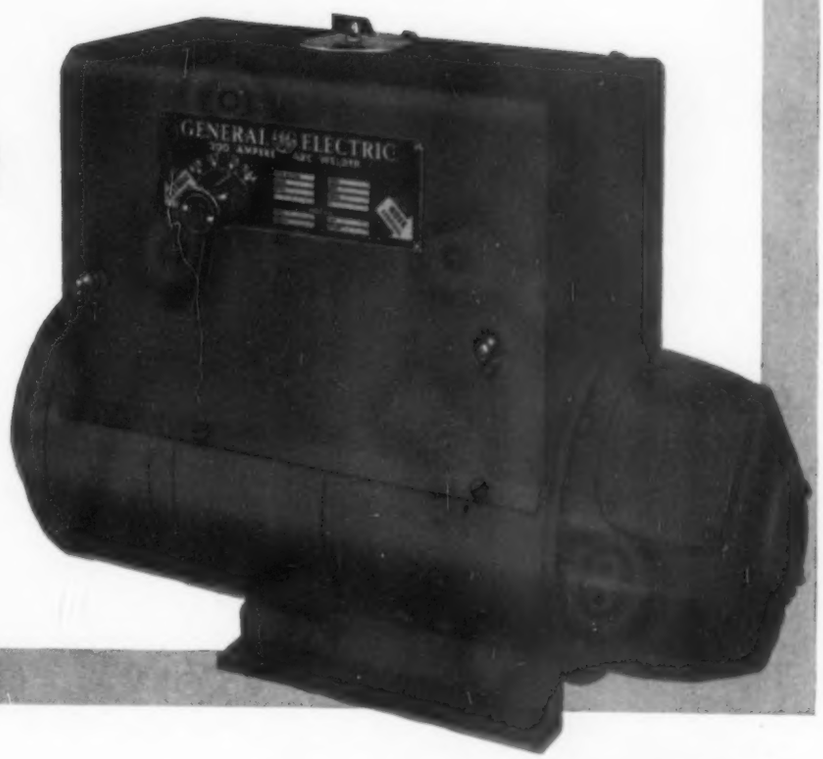
Some manufacturers who have hesitated to invest in larger machines for maintenance work find that the low price of this welder justifies keeping it on hand for emergency repairs.

# ALL TALKING..

## about the NEW 200-ampere G-E Direct-current Arc Welder

***At Lower-than-ever Prices***

Excellent performance over wide current range—25 to 250 amp—allows continuous manual welding with currents up to 200 amp and the use of our 1/16- to 3/16-inch electrodes, and even 1/4-inch electrodes for the occasional short job.




### ATTENTION!!

If you wish to take advantage of our easy-payment plan, you will find that this new welder more than pays its way when put to profitable use. Monthly income from such work should more than cover the small monthly payment, and still leave profit for you. Often the profit from just a single "emergency" job may be enough to almost pay for the welder.

Why not ask for a free demonstration, and put one of these new big-value welders to work in your shop today?

Call your nearest G-E arc welding distributor or G-E office, or mail the coupon to General Electric, Schenectady, N. Y. No obligation.

*General Electric Company, Section D 672-14, Schenectady, N. Y.*

*Gentlemen:*

*Please send me complete information on your new 200-amp welder, at no obligation. I have checked the information needed:*

*Descriptive Folder GES-2498* ___ *Easy Rental* ___

*Easy-payment Plan* ___

*Name* ..... *Title* .....

*Address* .....

*City* ..... *State* ..... 672-14

**GENERAL ELECTRIC**

## NEW SMALL WELDER

A new welder, the P&H-Hansen WD-150, recently placed on the market by the Harnischfeger Corporation of Milwaukee, measures less than 33 inches in length and one foot in height, but delivers uniform welding currents ranging from 200 down to 15 amperes.

Current selection is simplified by a single control on the WD-150. Once the current setting has been made, the generator automatically responds with the desired arc length under all welding conditions. Mis-synchronization of open circuit and arc voltage is impossible because of the automatic volt-ampere regulation, self-excitation and internal current stabilization of this machine.

A revolutionary departure from conventional welder construction is the square frame design of the WD-150.

With only three frame sizes, the manufacturer has produced a standardized line of spot welders ranging in electrical capacity from 10 to 50 kva.

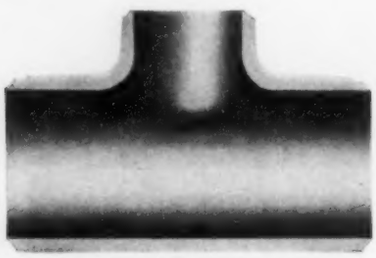
Horn lengths for various throat depths remain the only part of these welders to be added as orders are received and even in this, the most popular sizes are usually carried in stock so that shipments can be promptly made.

Reduced production costs, due to this standardization program, have, it is said, enabled the American Electric Fusion Corporation, Chicago, Ill., who conceived the idea, to appreciably reduce its price on all standard spot welders coming within the scope of this series.

## WELDING TEE

A new line of seamless steel-welding tees having several distinctive advantages has recently been developed by TUBE-TURNS, Incorporated, of Louisville, Kentucky.

The outstanding feature of this new tee is that full pipe strength is attained through the proper placing of metal at points of higher stress rather than by excess thickness throughout and consequent useless weight.

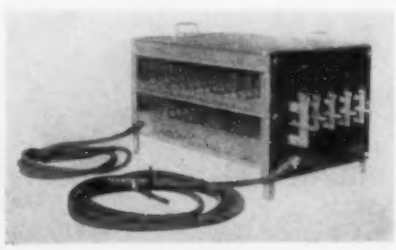


It has long been known that stresses due to internal pressure are highly concentrated at the intersection of the outlet with the run of a tee.

The new TUBE-TURN tee design meets this condition adequately by providing substantially more metal thickness at the crotch. The thickness from this point, that is, along the top centerline of the run of the tee, is gradually reduced to nominal at the bottom of the tee where stresses, when reinforcement at more highly stressed points is ample, again reach normal.

## ARC WELDER FOR MINE SERVICE

General Electric has announced a new resistor-type, d.-c. arc welder designed particularly for mine service. Portability and sturdy construction are among the chief features of this new welder.



It is only 17 inches high, 20 inches wide and 30 inches long, and weighs but 78 pounds. To withstand rough handling successfully, the resistor units are wound in continuous coils without joints and are supported by spool-type porcelain insulators. Enclosing screens protect the interior from falling material.

Welding current can be adjusted over the welding range, in 10 steps of approximately 17 amperes each, by means of five heavy knife switches. It is nominally rated at 250 volts, and will operate on a power line of 225 to 275 volts.

## SPOT-WELDER DESIGN

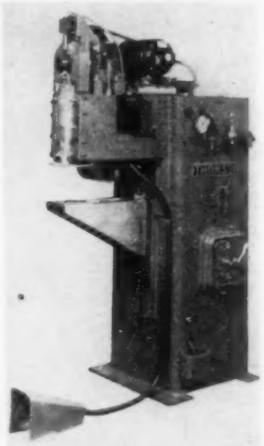
By standardizing on three (3) sizes of frames (see photo) all, however, bearing the same characteristics of design and interchangeable parts wherever possible, spot-welding machines to meet a wide range of application are now manufactured on a mass production basis.

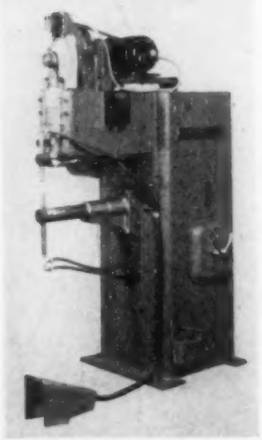
## THOMSON WELDING PRESS

Of paramount importance to any manufacturer investing in press-welding equipment is the unusual adaptability of the new Thomson Welding Press. Not only does the interchangeability of the essential parts result in important reductions in the original construction cost, but it is also possible at any time to remodel the machine to suit new requirements with a minimum of labor and expense.

For example, the machine originally purchased with a standard spring pressure head can be quickly converted to an air lock head type, or a machine with an apron mounted lower arm can be readily changed to a column mounted type or to a knee type machine for projection welding.

**Machine with Air Locked Head, Lower Knee and Flat Upper Terminal Pad**





**Standard Machine with Spring Head and Lower Arm Socket Bolted to Apron**

The following are some of the outstanding features of the new Thomson 1940 Model No. 1 Press Welder: stronger fabricated frame, adjustable head slide, cushioned cam action, efficient reduction unit, precision limit switch, micro-adjustable fan cams, wide range speed selection, maximum welding pressures and interchangeable pressure devices.

## Always Consider Resistance Welding

Federal Seam Welder. Pressure supplied by double acting air cylinder. Machine is spindle driven with roller cleaner on upper roller electrode.

# FEDERAL AUTOMATIC SEAM WELDER Solves Simple Problem in Arithmetic

Three Federal Seam Welders, installed by one of America's leading manufacturers, have paid for themselves in 2½ years and have shown, in addition, a net profit of $24,000. This was an annual saving of $18,000 over previous metal fabrication methods and product assembly. Pressure-tight welding was a requirement to be accomplished by this specially engineered installation.

This is but one of the many modern installations of Federal Resistance Welders being made constantly to improve methods of metal fabrication and assembly. By such new methods, manufacturers find greater possibilities for lowering costs, speeding up production, strengthening products and improving design.

Consider the application of resistance welding in your metal fabrication and assembly problems. Acquaint yourself with its unlimited possibilities. Twenty-nine years of Federal engineering experience is always at your service.

the Federal **FEDERAL MACHINE & WELDER CO.**

Literature available and inquiries given prompt attention.

In England, made by British Federal Welder & Machine Co. Ltd., Dudley, England

WARREN, OHIO

SALES OFFICES IN ALL PRINCIPAL CITIES

# » » » SECTION ACTIVITIES « « «

## CHICAGO

The Chicago Section is holdings its Second Annual Golf Tournament on Saturday, July 20, 1940, at Woodridge Golf and Country Club on Route 53, one and one-half miles south of Lisle, Illinois.

Exceptionally good facilities have been arranged for Chicago golfers with a total charge of $3.50 which will include lunch, dinner and golf all day. The Prize Committee is actively at work and if last year's tournament is to be any criterion, they will have a fine array of worth-while prizes for Chicago Section golfers to shoot at. Everyone in the Chicago area is cordially invited to attend, and full information, tickets, etc., can be obtained from the Chicago Section office, Room 731, 506 South Wabash Ave., Chicago, Ill.

The following individuals have been elected to serve as officers of the Chicago Section for the 1940–1941 period:

*Chairman*, L. S. McPhee, Whiting Corp.

*Vice-Chairman*, F. H. Carpenter, Pipe Weld, Inc.

*Secretary-Treasurer*, M. S. Hendricks, *The Welding Engineer*.

*Directors for three years:* Tom Harle, Graver Tank & Mfg. Co.; H. J. Kicherer, International Harvester Co.; J. H. Hruska, Electro-Motive Corp.; C. D. Young, Metal & Thermit Corp.

The final meeting of the 1939–1940 season was held on May 17th. There are no meetings of the Chicago group until the third Friday of September.

## GEORGIA

The Georgia Section had a very interesting and educational monthly meeting which was held on May 16th at the Atlantic Steel Company in Atlanta, Ga. Mr. R. W. Sandelin, Metallurgist for the Atlantic Steel Company, was the guide through the mills. He explained very thoroughly the operations of the different mills which were in operation at the time of the tour. There was a good attendance at this meeting and the Section is planning on another tour of the mills for the benefit of those who were unable to attend.

## KANSAS CITY

The following are the newly elected officers of the Kansas City Section for the coming year:

*Chairman*, Ned Ashton of Ash, Howard, Needles and Tammen.

*Vice-Chairman*, Preston Edwards, Granite City Steel Co.

*Secretary*, George Bain, Lincoln Electric Co.

*Treasurer*, Lester Morgan, Puritan Compressed Gas Corp.

*Executive Board:* (Manufacturers Group), R. G. Burge, Butler Manufacturing Co.; L. N. Williams, Black, Sivalls & Bryson, Inc.; J. L. Fizzell, National Steel Products Co.; (Suppliers Group) R. Clark, The Linde Air Products Co.; Ralph Koons, Puritan Compressed Gas Corp.; J. Kirk, Air Reduction Sales Company; Chas. Donegan, The Linde Air Products Co.

## LOS ANGELES

The following officers have been elected by the Los Angeles Section for the fiscal year.

*Chairman*, C. W. Roberts, Southwestern Eng. Co.

*Vice-Chairman*, J. C. Gowing, Hobart Bros. Co.

*Secretary-Treasurer*, E. C. Williams, Victor Equip. Co.

*Executive Committee:* H. L. Newby, Alexei Maradudin, Merrill Turner.

## NEW YORK

The New York Section enjoyed a World's Fair Day held on Saturday, June 8th. About 150 people attended the various sessions.

A most entertaining program was provided including visits to the following exhibits: Chrysler Motors, Railroads on Parade, B. F. Goodrich, Ford, Westinghouse, and General Electric.

The committee in charge of arrangements included the following: S. S. Scott, *Chairman;* Wayne Howard, *Secretary*, Miss M. M. Kelly, George Schneider, E. A. Kerbey, E. Vom Steeg, Jr., A. O'Neal, Charles Kandel, A. Seemen, J. T. Phillips, H. Sussman, A. Haller, H. L. Rogers, J. F. Callahan, J. B. Tinnon, W. S. Shoenthaler, A. Lindquist, W. H. Borst, J. L. Wilson, A. F. Keogh, E. C. Rechtin, B. Brower, C. W. Obert, R. E. Bedworth, A. E. Gaynor, C. A. McCune, J. Rosencrans, B. A. Russell, D S. Jacobus.

About 75 people attended the dinner at Schaeffers Center.

## NORTHERN NEW YORK

The annual business meeting of the Northern New York Section was held at the New Kenmore Hotel, Albany, N. Y., May 23rd. Following the dinner and entertainment, reports were given by the various officers and committees. The Section was fortunate in having present Dr. Wendell F. Hess, Divisional Vice-President of the New York & New England Division, A. W. S., who outlined many of the activities of the Society.

Officers for the year 1940–1941 are as follows:

*Chairman*, W. C. Hutchins, General Electric Co.

*1st Vice-Chairman*, E. F. Potter, General Electric Co.

*2nd Vice-Chairman*, M. F. Sayre, Union College.

*Secretary-Treasurer*, W. W. Churchill, General Electric Co.

*Executive Committee:* (Terms expire as follows) E. R. Spittler, 1941; E. J. Ramer, 1941; F. H. Miller, 1942; G. G. Somerville, 1942; J. J. Lipsky, 1943; R. W. Clark, 1943.

## NORTHWEST

The third annual meeting of the Northwest Section was held May 21, 1940, and was purely a business meeting without a speaker, but with some entertainment.

The reports of officers showed a very satisfactory condition of the Section, and plans were laid for activities during the coming year which would result in greatly increased membership and interest on the part of the members.

The following officers and members of Executive Committee were elected for the ensuing year:

*Chairman*, T. P. Hughes, University of Minnesota.

*Vice-Chairman*, J. H. Barron, Stainless Steel Products Co.

*Secretary-Treasurer*, Alexis Caswell, Manufacturers Assn. of Minn.

*Executive Committee:* C. M. Atkins, F. O. Borne, C. E. Comfort, G. C. Hill, G. W. Irwin, L. T. Kenney, H. A. Lindeke, John Mikulak, W. E. Murphy, J. Nelson, R. H. Newton, R. W. Robinson, R. L. Spaulding, T. J. Warmington, J. E. Williams.

## OKLAHOMA CITY

The following officers and members of Executive Committee have been elected by the Oklahoma City Section for 1940–1941.

*Chairman*, K. B. Banks, Box 1377.

*Vice-Chairman*, C. C. Willis, Box 1498.

*Secretary*, Francis Sprehe, Midwest Steel Co.

*Treasurer*, W. D. Brewer, Oklahoma Gas & Elec. Co.

*Executive Committee:* (for 2 years) J. L. Lang, Otto Hart, W. T. Tiffin, M. L. Mossholder; (for 1 year) B. O. Underwood, Justin Roach.

The June meeting of the Section was held on the 6th at the Biltmore Hotel.

*Throughout Industry . . .*

# HARD-FACING REDUCES MATERIAL COSTS

## "Drawing-Out" Rod for Smaller Sizes

THE hard-facing of small parts occasionally requires Haynes Stellite rod of smaller size than is at hand. As shown at the left, large rod, 3/8-in. or 5/16-in. for example, can be easily "drawn out" to a smaller size. With the excess acetylene flame playing on the end of the rod, a drop is laid on a cold, grooved plate of carbon, graphite, iron, or steel, and the rod is drawn away at a steady rate, leaving a small rod deposited in the groove.

Hard-facing of small parts is illustrated by this pivot-bar of a water-

heater thermostat. Each end of the pivot-bar (shown mated with a support bar) is wearproofed with a drop of Haynes Stellite rod. *This application is an example of how hard-facing reduces material costs since special steel inserts were used before hard-facing was adopted.*

If you are doing any hard-facing, Haynes Stellite engineers or Linde service operators can show you many other handy short cuts. Call on them without obligation.

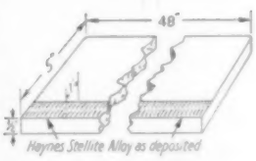
*Headquarters for Hard-Facing Materials*

HAYNES STELLITE COMPANY
*Unit of Union Carbide and Carbon Corporation*
UCC
New York, N. Y. Kokomo, Indiana

"Haynes Stellite" is a registered trade-mark of Haynes Stellite Company

## Hard-Facing Hints

SCRAPER BLADES—The life of underground scraper blades like those sketched has been increased 3 to 4 times at one mine by hard-facing the blades with Haynes Stellite rod. Further savings are obtained by using machine steel as a base metal for the hard-facing alloy where high-carbon steel blades were formerly required. The sketch gives the dimensions of the blade and the extent of the hard-facing deposit.



STAMPING DIE—Hard-facing this stamping and forming die for oil can ends with Haynes Stellite alloy permitted the substitution of mild steel for more expensive tool steel. Because the life between grinds was increased about nine times, the hard-faced dies eliminated nearly 90 per cent of the shutdowns for regrinding. Under normal conditions each of the dies makes approximately 20,000 cuts per day.

Hard-facing applications in many industries are described and illustrated in the book, "Hard-Facing With Haynes Stellite Products." A copy will be sent to you on request to Kokomo, Indiana, or the nearest district office—Chicago, Cleveland, Detroit, Houston, Los Angeles, New York, San Francisco, Tulsa.

HAYNES STELLITE
TRADE MARK
*Red-hard, wear-resisting alloy of cobalt, chromium and tungsten*

There were 62 members and guests present.

The principal speaker, Mr. E. R. Fish, Chief Engineer of the Hartford Steam Boiler Insp. & Ins. Co. of Hartford, Conn., presented an interesting address on "Inspection of Welds," which was elaborated by slides of tests and pictures of welding failures. The subject was well received and Mr. Fish graciously answered a number of questions addressed to him.

### PUGET SOUND

On Friday afternoon, May 10th, the Seattle Section organized an autocaravan and proceeded to Tacoma, Wash., where they made an inspection trip of the welding work being done by the Seattle-Tacoma Shipbuilding Co. on the new type C-I cargo carriers which this company is building. They were joined in Tacoma by several members and their guests and altogether 75 men made the inspection trip through the Yard. This Shipbuilding Company is using many types of welding processes, and the trip was very instructive. After the inspection trip, 62 members and their guests repaired to the University Union Club in Tacoma where they enjoyed a social hour before dinner, and after dinner were addressed by Mr. Sidney Smith, Seattle District Surveyor for the American Bureau of Shipping. This was one of the most successful meetings held.

### ROCHESTER

The following are the officers and Executive Committee of the Rochester Section for 1940–1941.

*Chairman*, F. L. Pfeiffer, F. L. Heughes and Co., Inc.

*Vice-Chairman*, W. T. Morgan, Taylor Instrument Cos.

*Secretary*, P. W. James, Lincoln Electric Co.

*Executive Committee:* E. A. Allan, R. L. Cattanach, W. J. Conley, T. S. Gaylord, E. L. Hand, P. A. Ecklund.

### SAN FRANCISCO

The following officers and chairmen of committees were elected for the ensuing year:

*Chairman*, Harold Chaney, Bethlehem Steel Co.

*Vice-Chairman*, Frank Longo, Southern Pacific Co.

*Secretary*, J. G. Bollinger, Air Reduction Sales Co.

*Treasurer*, H. W. Saunders, Air Reduction Sales Co.

*Executive Committee:* (three years) T. R. Rooney; (one year) E. L. Mathy; (two years) N. F. Ward.

*Membership Committee Chairman:* M. Maltseff, Western Pipe & Steel Co.

*Program Committee Chairman:* Frank Longo, Southern Pacific Co.

*Ways and Means Committee Chairman:* R. O. Waldman, Chicago Steel & Wire Co.

*Educational Committee Chairman:* Prof. N. F. Ward, University of Calif.

The final meeting of the season 1939–1940 was held on May 7th. The speaker of the evening was Mr. Bob Sturgess of the Standard Oil Company, who spoke on "Stress Analysis." Mr. Sturgess' discussion included a demonstration of his subject by means of transmitting polarized light through celluloid models.

### SOUTH TEXAS

Meeting of the South Texas Section was held on April 26th. A review of the JOURNAL OF THE AMERICAN WELDING SOCIETY was made by Mr. E. W. Pittman, of the Petroleum Iron Works. Mr. E. C. Jackson of The Southern Pacific Lines reviewed *The Welding Engineer*. A lively discussion ensued concerning the stress relief of metal by heat treatment, and other methods. This meeting was one of the best held in recent months.

### WESTERN NEW YORK

The Western New York Section held its regular monthly meeting May 16th in the Electric Building, Buffalo, N. Y. At this meeting the results of election of officers and directors were announced. They are as follows:

*Chairman*, Geo. M. Trefts, III.

*Vice-Chairman*, Geo. E. Schliecker.

*Secretary*, D. W. Patterson, Federal Machine & Welder Co.

*Treasurer*, Robert Siemer, Allan Mfg. & Welding Co.

*Directors for two years:* W. R. Gordon, J. K. Bard.

*Directors for one year:* John Bos, T. H. Speller.

The speaker of the evening was Mr. Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Co. His subject was "Shrinkage, Locked-Up Stresses, and Welding Procedures." There was an attendance of 65 members and guests. His talk was very enthusiastically received and the speaker was kept more than an hour after his talk answering questions.

### YORK-CENTRAL PA.

The regular monthly meeting of this Section was held on May 23rd at the American Legion Home, Waynesboro, Pa. Mr. H. W. Lawson, an engineer in the Fabricated Steel Construction Department of the Bethlehem Steel Company, presented an extremely interesting address on "Welding in Modern Structures."

The June meeting was held on the 12th at the Engineering Society of York Building. Mr. George A. Jessop, Chief Engineer of S. Morgan Smith Company, presented an illustrated talk on "Economic Production of Heavy Welded Parts." The first welded fabrication of large hydraulic turbine parts was due in a large measure to the pioneering efforts, foresight and initiative of Mr. Jessop. Since 1937 when this policy was inaugurated the S. Morgan Smith Company has built or have under construction at the present time nine large turbine units alone which involve 71,400 feet of gas cutting, 106,000 linear feet of welding, using 258,000 pounds of electrodes and 5,800,000 pounds of rolled plate steel. Mr. Jessop's talk was well illustrated with slides and covered the different phases of shop production and methods used in fabrication.

---

## EMPLOYMENT SERVICE BULLETIN

### POSITION VACANT

V-95. Instructor to teach Welding and assist in Machine Shop in engineering college. Salary eighteen hundred for academic year. Apply, giving qualifications and small photograph, to Professor of Mechanical Engineering, Drexel Institute of Technology, Philadelphia, Pa.

### SERVICES AVAILABLE

A-354. High school graduate, 25 years of age. Completed courses in Electric and Gas Welding in all positions. While at school was given opportunity to do actual work under supervision, equivalent to six months' experience. Willing to travel, but would prefer work in New York.

A-362. Welding Supervisor, Foreman, Inspector. Twenty years' experience repair work, manufacturing, structural fabrication, pipe systems, arc or gas; blueprints. Desire responsible position.

A-363. Electrical Engineer. Graduated June 1940. Also a Certificate of Technical Welding, June 1940. Age 24, married. Two years' experience welding for Oklahoma A. and M. College. One year service in Army 2d Lt. Inf.-Res. stationed at Fort Warren, Wyoming, under Thomason Act (valuable experience in handling men). Expert welder, gas and electrical, on ferrous, alloys and non-ferrous metal. Desires engineering, maintenance or supervisory work in welding field. Will work anywhere.

---

### UNITED STATES CIVIL SERVICE EXAMINATIONS

Inspector, Ordnance Material, $2300 a year; also Senior, $2600; Associate, $2000; Assistant, $1800; and Junior, $1620 a year Ordnance Department, War Department

Original Announcement No. 124 is hereby amended to extend the closing date for receipt of applications. Applications will be accepted by the U. S. Civil Service Commission at Washington, D. C., *UNTIL FURTHER NOTICE*. Applications will be considered and rated approximately as received, unless an eligible register sufficient to meet the needs of the service is obtained, in which event due notice will be given.

---

### BOOK

Oxyacetylene Welding (Technique et Pratique de la Soudure Autogène Oxy-Acétylènique) by R. Granjon and R. Meslier. First Edition, published by Institut de Soudure Autogène, Paris (1939), 160 pages, 15 francs. A practical book on apparatus and methods written by the Director and Chef des Travaux of the French Institute of Welding.

# Don't Buy Any Welder Until You Make The *FLEXARC 200-FOOT TEST*

For 200 feet or similar long cable runs — there's no running back to a FlexArc for readjustments.

**RENT A FLEXARC AND GIVE IT AN ON-THE-JOB TEST**

Here's a real showdown! Rent a FlexArc—see how it stacks up in *your* hands, on *your* job. Easy terms—no obligation to buy. Rental can be applied against purchase price.

Stop in today at any Westinghouse dealer's and make the FLEXARC 200-FOOT TEST. It's a revelation in what you can do with a modern FlexArc Welder.

Just pre-set FlexArc's ONE control—walk off 200 feet, or more, to the job—and weld.

Watch FlexArc give you *automatically* the exact arc you need for any position of the rod—downhand, vertical, overhead, or all in quick succession. Note how current readjustments after warm up are unnecessary—how you never have to chase back to the machine whether you weld for five minutes or five hours.

Consider what these features can mean to you—ability to lay down more metal per hour than you ever did before—no lost time walking back to the machine—better welds because the arc's always right. You'll agree—it pays to make the FLEXARC 200-FOOT TEST before you buy any welder!

WESTINGHOUSE ELECTRIC & MFG. CO.
DEPT. 7-N EAST PITTSBURGH, PA.

J-21067

**Westinghouse Flexarc Welders**

WESTINGHOUSE ELECTRIC

# List of New Members

**May 1st to May 31, 1940**

### BOSTON

**Cota, J. Arthur** (D), 1 Main St., Farnumsville, Mass.
**De Marco, John P.** (D), 35 Westminster St., Springfield, Mass.
**Gardner, Norman B.** (C), % N. Y. N. H. & H. R. R. Co., Room 408, Providence, R. I.
**Josleyn, W. M.** (D), 171 Brookline St., Cambridge, Mass.
**White, Louis** (D), 71 Cleverly Court, Quincy, Mass.

### CANADA

**Trimblay, L.** (D), 46—5 Ave., Limoilon, Que., P.2, Canada.

### CHICAGO

**Frank, A. A., Jr.** (C), 800 Sheridan Rd., Evanston, Ill.
**Harle, Thomas D.** (B), 221 Warren St., Calumet City, Ill.

### CINCINNATI

**Collins, Forrest L.** (D), Cincinnati Gas & Elec. Co., Columbia Park, Ohio.
**Fugate, R. G.** (C), Williams & Co. Henry & Dunlap St., Cincinnati, Ohio.
**Gray, Warren** (D), 1909 Western Ave., Cincinnati, Ohio.
**Petry, L. W.** (C), 918 Delaware Ave., Middletown, Ohio.
**Stav, Carl W.** (D), 231 Mason St., Cincinnati, Ohio.

### CLEVELAND

**Bramley, Jack W.** (D), 1602 Carlyon Rd., Cleveland, Ohio.
**Gates, A. J. Jr.** (C), Una Welding Co., 1615 Collamer Ave., Cleveland, Ohio.
**Gerchman, Anthony** (D), 1563 Larchemont Rd., Cleveland, Ohio.
**Morrill, John R.** (C), Lincoln Elec. Co., 12818 Coit Rd., Cleveland, Ohio.
**Olds, Milroy L.** (C), 1952 Laurelhill Dr., So. Euclid, Ohio.
**Smith, John W.** (D), 14203 Ardenall Ave. E., Cleveland, Ohio.

### COLUMBUS

**Beiers, Ernest** (B), 4520 Kenney Rd., Columbus, Ohio.

### DETROIT

**Neitzel, Henry** (C), Whitehead & Kales Co., River Rouge, Mich.
**Specht, George** (D), 1227 High St., Windsor, Ont., Canada.

### LOS ANGELES

**Livermore, Claude F.** (C), 3341 E. Slauson Ave., Los Angeles, Calif.
**Weeks, Charles S.** (C), 6415 Haas Ave., Los Angeles, Calif.
**Williams, E. O.** (C), Victor Equip. Co., 3821 Santa Fe Ave., Los Angeles, Calif.

### MILWAUKEE

**Lindsay, J. A.** (F), Hotel Carlton, Rm. 43, Milwaukee, Wis.
**Radway, Lawrie C.** (C), Ampco Metal Inc., 3830 W. Burnham St., Milwaukee, Wis.
**Stari, Joe** (F), 938 N. Milwaukee St., Milwaukee, Wis.
**Wyse, Robert W.** (C), 3306 N. 29th St., Milwaukee, Wis.

### NEW YORK

**Armstrong, Robert J.** (D), 2989 Marion Ave., Bronx, N. Y.
**Lauria, Thomas** (D), 529 W. 149th St., New York, N. Y.
**Miller, Frank A.** (B), Dept. of Housing & Bldgs., Municipal Bldg., Manhattan, New York, N. Y.
**Murphy, J. J.** (B), Linde Air Products Co., 30 E. 42nd St., New York, N. Y.
**Myck, Harold** (D), 268—89th St., Brooklyn, N. Y.
**Schwartzberg, Jack** (C), 1631 Walton Ave., Bronx, N. Y.
**Smizawski, John J.** (D), 2025—43rd St., Astoria, L. I., N. Y.

### NORTHERN NEW JERSEY

**Dorer, Chas. A.** (D), 207 Murray St., Newark, N. J.
**Foley, Irving S.** (D), 127 Grafton Ave., Newark, N. J.
**Gaffney, John J.** (C), 529—40th St., North Bergen, N. J.
**McDonald, A. J.** (B), American Steel Castings Co., Avenue L & Ed. St., Newark, N. J.
**Payne, Leonard W.** (C), 395 Union Ave., Belleville, N. J.
**Robinson, Charley** (D), 62 Treacy Ave., Newark, N. J.
**Strafhel, Albert** (D), 28 Boylan St., Newark, N. J.
**Weber, William** (D), 531 So. 21st St., Irvington, N. J.
**Wheeler, K. V.** (B), American Steel Castings Co., Avenue L & Ed. St., Newark, N. J.

### NORTHERN NEW YORK

**Garman, George W.** (C), General Electric Co., Schenectady, N. Y.

### WESTERN NEW YORK

**Bayer, Frank** (D), 266 Hazelwood Ave., Buffalo, N. Y.
**Morrison, Ralph M.** (C), Buffalo Tank Corp., Box 16, Buffalo, N. Y.
**Mungovan, Thomas J.** (B), Vanott Mach. Corp., 216 Colgate Ave., Buffalo, N. Y.

### NORTHWEST

**Bush, Ray G.** (B), Westinghouse E. & M. Co., 2303 Kennedy St., Minneapolis, Minn.
**Gorans, Victor** (D), 1643 Taylor Ave., St. Paul, Minn.
**Harding, Forest** (D), Harding Metal Works, Bismarck, N. Dakota.
**Menefee, Chester** (D), 2827 Polk St., N. E., Minneapolis, Minn.
**Simonsen, E. N.** (D), 3836 Longfellow Ave., Minneapolis, Minn.
**Zech, Chester** (D), 3323—41st Ave. S., Minneapolis, Minn.

### OKLAHOMA CITY

**Gaines, N. J.** (D), General Mfg. Co., Box 391, Okmulgee, Okla.

### PHILADELPHIA

**Soriano, Ernest** (B), City Hotel, 301—3rd & Edgmont Ave., Chester, Pa.

### PITTSBURGH

**Ehrhardt, Paul T.** (D), 1004 Washington Ave., McKeesport, Pa.
**Thompson, H. C.** (D), Grandview Ave., Glenshaw, Pa.
**Van Horne, C. F.** (D), Air Reduction Sales Co., 200 Summit Ave., Johnstown, Pa.
**White, Alfred B.** (C), 100 Braddock Rd., Forest Hills, Pittsburgh, Pa.

### PUGET SOUND

**Rock, Allen A.** (B), Hobart Equip. Co., 1925—1st Ave. S., Seattle, Wash.

### ROCHESTER

**Rittler, Carl** (D), R. D. 1, N. Washington, Brighton Sta., N. Y.

### SAN FRANCISCO

**Brink, Harrison S., Jr.** (D), 1304 Jenevien Ave., San Bruno, Calif.
**Evans, James K.** (C), 735 El Camino Blvd., Burlingame, Calif.
**Maltseff, Michael N.** (B), 1466—17th Ave., San Francisco, Calif.
**Mannion, Thomas F.** (D), 361—14th St., San Francisco, Calif.
**Sumarokoff, Nicholas** (C), Western Pipe & Steel Co., South San Francisco, Calif.
**Todd, Andrew F.** (D), 1459 Willard St., San Francisco, Calif.

### SOUTH TEXAS

**Grafton, J. A.** (C), 423 Clifton St., Houston, Texas.
**Wait, J. R., Jr.** (B), J. S. Abercrombie Co., 2105 Gulf Bldg., Houston, Texas.

### TULSA

**Branson, I. L.** (D), 711½ N. Atlanta, Tulsa, Okla.
**Coleman, C. A.** (D), 717 North Zenis, Tulsa, Okla.
**Krause, H. E.** (C), Moorlane Co., 409 E. Archer, Tulsa, Okla.
**Louree, C. H.** (D), 3312 E. 3rd, Tulsa, Okla.
**Meyer, William J.** (D), 2647 E. 1st, Tulsa, Okla.
**Montgomery, J. A.** (D), 3523 E. Haskell, Tulsa, Okla.

This is NEWS!
New York, N. Y., April 26, 1940
Volume I—No. 6
NATIONAL METAL EXPOSITION SPACE OVER-SUBSCRIBED SEVEN MONTHS IN ADVANCE OF OPENING OCTOBER 21
Private Buildings Erected by 38 Companies At Tulsa Show
A M A Will Use Four Floors at N. Y. Meet
HEAVY DEMAND FOR METAL SHOW SPACE MORE TO BE ADDED
Over 86,000 Square Feet Reserved—More Space Than Used in 1939

## ...NEWS THAT MEANS MORE SALES FOR METAL EXPOSITION EXHIBITORS

When this story broke in the newspapers, metal men forgot political news for a while—forgot World War No. 2—and started to speculate about this biggest National Metal Exposition which will open in October at Cleveland.

If this is the biggest Metal Exposition in 22 years, they said, we'd better be there to get our share of the business. Because last year 33,000 of our best prospects attended the Metal Exposition.

And so . . . to the Metal Exposition headquarters in Cleveland . . . have come letters, wires and telephone calls by the dozens. Reserving spaces for big and little companies who sell the metal industry everything from pyrometers to tons of steel.

But there are still plenty of good spaces left at the regular $1.00 a square foot rate because Cleveland's ample Public Auditorium provides more than 150,000 square feet for the Metal Exposition.

So write or wire collect today for full particulars. Address: W. H. Eisenman, Director, National Metal Exposition, 7301 Euclid Avenue, Cleveland, Ohio.

The WORLD'S GREATEST EVENT IN THE METAL INDUSTRY 70% NEW ATTENDANCE EACH YEAR

**COOPERATING SOCIETIES**

American Society for Metals
Wire Association
American Welding Society
Iron & Steel Division and Institute
of Metals Division of the American Institute
of Mining & Metallurgical Engineers

# NATIONAL METAL EXPOSITION

AND METAL CONGRESS

OCTOBER 21-25, 1940 *Cleveland, Ohio*

MANAGED BY AMERICAN SOCIETY FOR METALS

**Poole, A. C.** (D), 3146 E. Latimer, Tulsa, Okla.
**Saunders, J. W.** (D), 1628 E. Easton, Tulsa, Okla.

### WASHINGTON, D. C.

**Erwin, Frank J.** (C), 6018 No. 21st St., Arlington, Va.
**Maurer, W. J.** (C), 1713 K Street N.W., Washington, D. C.
**Quasebarth, Norman A.** (C), 1318 Half St. S.E., Washington, D. C.
**Schwartz, James E.** (C), General Elec. Co., Shoreham Bldg., Washington, D. C.

### WICHITA

**Drake, G. E.** (C), Linde Air Prods. Co., Wichita, Kans.

### NOT IN SECTIONS

**Beck, William A.** (C), % Linde Air Prods. Co., P. O. Box 1222, Charleston, W. Va.
**Bhagat, N. B.** (A), Bhagat & Sons, Siwri Fort Rd., Bombay, 15, India.
**Blossom, D. E.** (D), 4 Otis St., P. O. Box 945, Manila, P. I.
**Fehlen, Mathias J.** (B), Dura Co., 4500 Detroit Ave., Toledo, Ohio.
**Furr, John A., Jr.** (D), 1310 Beuna Vista St., Pascagoula, Miss.
**Haag, Paul H.** (C), % Sao Paulo Tramway, Light & Power Co., New Construction Dept., Caixa Do Correio A, Sao Paulo, Brazil.
**Hogan, Howard K.** (B), 2301 E. Washington St., Apt. 3, Charleston, W. Va.
**Perry, C. S.** (C), 607 Tuttle Ave., Horseheads, N. Y.
**Wise, Marshall** (D), 2 Judith St., Charleston, S. C.

---

## TO DIRECT RESEARCH FOR METAL & THERMIT CORP.

Dr. Lincoln T. Work, Associate Professor of Chemical Engineering at Columbia University, has been appointed Director of Research of the Metal & Thermit Corporation, New York, N. Y.

Beginning July 1, 1940, all of the corporation's research and development activities, including work in electric arc and Thermit welding, pigments, metals and alloys and various phases of chemical and metallurgical engineering, will be under his supervision.

Born in Hartford, Connecticut, Dr. Work was graduated from Columbia University in 1918 and received his degree of Doctor of Philosophy from there in 1929. He has been successively instructor, assistant professor and associate professor of chemical engineering at Columbia, where he helped to create and establish a process development course, supervised chemical engineering thesis projects for the doctorate, organized and directed a course in chemical engineering principles for men in industry and served as assistant to the Director of Extension Teaching and to the Dean of Engineering in charge of the Engineering School's Men in Industry Program.

In addition, Dr. Work has conducted research for a number of industrial concerns in the cement and clay, paint and varnish, air conditioning, plastics, pulp and paper, and pulverized coal fields, and organized a division of fundamental research for one of the country's largest corporations in the chemical engineering industry.

Dr. Lincoln T. Work

Dr. Work is a member of a number of honorary fraternities and professional societies, including American Institute of Mining and Metallurgical Engineers, Electro-Chemical Society, American Institute of Chemical Engineers, American Chemical Society, Society of Chemical Industry and American Society for Testing Materials, in many of which he has held various offices and done important committee work. He also is a member of several committees of the National Research Council and the American Standards Association. The American Section of the Society of Chemical Industry has elected him as its chairman for the coming year. He is also the author of a number of publications on chemical engineering subjects.

## OBITUARY
### Oscar B. McLaughlan

Mr. Oscar B. McLaughlan, Sustaining Member, of the Freeport Sulphur Company, Port Sulphur, La., in the AMERICAN WELDING SOCIETY, died in April. Mr. McLaughlan was born in Ireland Nov. 26, 1885. He came to this country while still a very young man and lived here throughout the remainder of his lifetime. He was employed by the Freeport Sulphur Company during the last seventeen years in the capacities of Shop Foreman and Master Mechanic. He was chairman of the Louisiana Section of the AMERICAN WELDING SOCIETY.

---

## CRYPT OF CIVILIZATION SEALED FOR 6000 YEARS

A crowd of some 2500 people gathered recently at Oglethorpe University, Atlanta, Ga., to witness the sealing of the Crypt of Civilization. A result of several years of intense research and collection, the Crypt—a vault in the Administration Building at Oglethorpe—contains records of present-day science and civilization. It is not to be opened until 8113 A.D.

Among the many articles enclosed in the Crypt are motion pictures, recordings of speeches, wearing apparel, miniature copies of literary masterpieces, etc. As a matter of fact, the Crypt contains just about everything used in the civilization of today, plus material available from the past.

Preservation of items, such as cloth and film, which would ordinarily deteriorate with age, was accomplished in the Crypt by the use of Airco nitrogen. These perishable articles were placed in glass or metal containers which were then evacuated of all air. When this was done, the containers were filled with nitrogen and carefully sealed. This procedure is an indication of the extreme precautionary measures taken to assure a monument worthy of modern science.

Dr. Thornwell Jacobs, President of Oglethorpe University, Evacuates and Fills with Airco Nitrogen the First Glass Container for the Crypt of Civilization. It Contains a Micro Film of the Bible

Dr. Jacobs and Dr. Peters of Oglethorpe University Observe Supervisor J. P. Flood of Air Reduction as He Seals the Crypt of Civilization with a Wilson "Hornet" Electric Welder

Quite appropriately this 2000-cubic-foot vault was sealed in a modern manner—welded with arc welding.

# *Sections*—CHAIRMEN, SECRETARIES AND REGULAR MEETING DATES

**BIRMINGHAM** 3rd Fri.
CHAIRMAN—J. W. ADAMS, 209 No. 52nd St., Birmingham, Ala.
SECRETARY-TREAS.—W. L. POOLE, Air Reduction Sales Company, 2825 No. 29th Ave., Birmingham, Ala.

**BOSTON** 2nd Mon.
CHAIRMAN—F. B. MEHAFFEY, Air Reduction Sales Co., 122 Mt. Vernon St., Upham Crs., Dorchester, Mass.
SECRETARY—P. N. RUGG, 8 Eastern Ave., Wakefield, Mass.

**CHATTANOOGA, TENN.** 1st Wed.
CHAIRMAN—A. R. McLAIN, 622 Georgia Avenue, Apt. 110 Chattanooga, Tenn.
SECRETARY—J. H. WEIGEL, Combustion Eng. Co., Chattanooga, Tenn.

**CHICAGO** 3rd Fri.
CHAIRMAN—L. S. McPHEE, Whiting Corp., Harvey, Ill.
SECRETARY—M. S. HENDRICKS, Welding Engineer, Room 731, 506 South Wabash Avenue

**CINCINNATI, OHIO**
CHAIRMAN—ERIC O'HARA, Cincinnati, Gas & Elect. Co., Cincinnati, Ohio
SECRETARY—R. G. FUGATE, Williams & Co., Inc., Cincinnati, Ohio

**CLEVELAND** 2nd Wed.
CHAIRMAN—F. L. PLUMMER, 2591 Charney Rd.
SECRETARY-TREAS.—A. LESLIE PFEIL, Universal Power Corporation, Cleveland, Ohio

**COLORADO** 3rd Wed.
CHAIRMAN—J. H. JOHNSON, Johnson Supply Co., Denver, Colo.
SECRETARY-TREAS.—H. W. CREAGER, Hendrie & Bolthoff Mfg. & Supply Co., Denver, Colo.

**COLUMBUS, OHIO** 2nd Fri.
CHAIRMAN—F. S. CALDWELL, Jeffrey Mfg. Co., Columbus, Ohio
SECRETARY—G. S. HERREN, The Seagrave Corp., Columbus, Ohio

**CONNECTICUT** 1st Tues.
CHAIRMAN—JOHN J. VREELAND, Chase Brass & Copper Co., Waterbury, Conn.
SECRETARY—H. A. PENNINGTON, A. B. King & Co., 196 Chapel Street, New Haven, Conn.

**DETROIT** 1st or 2nd Fri.
CHAIRMAN—H. P. DOUD, General Electric Co., 700 Antoinette, Detroit
SECRETARY—O. L. SMITH, Weldit Acetylene Co., 638 Bagley, Detroit, Mich.

**GEORGIA** 1st Fri.
CHAIRMAN—D. B. HUNT, 484 Brentwood Dr. N. E., Atlanta, Ga.
SECRETARY—H. J. LEE, P. O. Box 4564, Atlanta, Ga.

**HAWAII** Last Thurs.
CHAIRMAN—ROBERT A. PLAUS, W. A. Ramsay, Ltd., Honolulu, T. H.
SECRETARY—ALAN G. SLIPPER, Hawaiian Gas Products Co., P. O. Box 2454, Honolulu, T. H

**INDIANA**
CHAIRMAN—A. C. RASMUSSEN, Insley Mfg. Corp., Indianapolis, Ind.
SECRETARY—G. HAISLUP, Electric Steel Castings Co., Speedway City, Indianapolis, Ind.

**KANSAS CITY, MO.** 3rd Mon.
CHAIRMAN—N. ASHTON, Ash, Howard, Needles & Tammen, Kansas City, Mo.
SECRETARY—GEORGE BAIN, Lincoln Electric Co., Kansas City, Mo.

**LAKE SHORE**
CHAIRMAN—A. W. WIEMANN, Armour Leather Co. Sheboygan, Wis.
SECRETARY—R. E. KING, 1308-A Hamilton St. Manitowoc, Wis.

**LOS ANGELES** 3rd Thurs.
CHAIRMAN—C. W. ROBERTS, Southwestern Eng. Co., Los Angeles, Calif.
SECRETARY—E. O. WILLIAMS, Victor Equip. Co., Los Angeles, Calif.

**LOUISIANA** 1st Fri.
SECRETARY—CLYDE PINE, The Isaac Delgado Trade School, New Orleans, La.

**MARYLAND** 3rd Fri. except April
CHAIRMAN—R. A. MANSFIELD, Southern Oxygen Co., Baltimore, Md.
SECRETARY-TREAS.—W. M. H. BALLATYNE, Penn. Water & Power Co., Baltimore, Md.

**MILWAUKEE** 2nd Wed.
CHAIRMAN—R. W. STERNKE, Lakeside Bridge & Steel Co., Milwaukee, Wis.
SECRETARY—GILBERT F. MEYER, Machinery & Welder Corp., Milwaukee, Wis.

**NEW YORK** 2nd Tues. except when Joint Meeting is held
CHAIRMAN—J. T. PHILLIPS, Foster Wheeler Corp., Carteret, N. J.
SECRETARY—WAYNE A. HOWARD, Socony-Vacuum Oil Corp., Brooklyn, N. Y.

**NORTHWEST** 3rd Wed.
CHAIRMAN—T. P. HUGHES, University of Minn., Minneapolis, Minn.
SECRETARY—ALEXIS CASWELL, Manufacturers Assoc. of Minn., 200 Builders Exchange Bldg., Minneapolis, Minn.

**NORTHERN NEW JERSEY**
CHAIRMAN—F. C. FYKE, Standard Oil Development Co., Elizabeth, N. J.
SECRETARY—H. S. CARD, 449 Elmora Ave., Elizabeth, N. J.

**NORTHERN N. Y.** Last Thurs.
CHAIRMAN—W. C. HUTCHINS, General Electric Co., Schenectady, N. Y.
SECRETARY—W. W. CHURCHILL, General Electric Co., Schenectady, N. Y.

**OKLAHOMA CITY** 1st Fri.
CHAIRMAN—K. B. BANKS, P. O. Box 1377, Oklahoma City, Okla.
SECRETARY—F. SPREHE, Midwest Steel Co., Oklahoma City, Okla.

**PEORIA—CENTRAL ILLINOIS**
CHAIRMAN—E. E ISGREN, R. G Le Tourneau, Inc., Peoria, Ill.
SECRETARY—ALBERT A LOSCH, R. G. Le Tourneau, Inc., Peoria, Ill.

**PHILADELPHIA** 3rd Mon.
CHAIRMAN—H. W. LAWSON, 243 E. Church St., Bethlehem, Pa.
SECRETARY—H. E. HOPKINS, Arcos Corp., 401 N. Broad St., Phila., Pa.

**PITTSBURGH** Middle Wed.
CHAIRMAN—G. F. WOLFE, Dravo Corp., Engineering Wks. Div., Pittsburgh, Pa.
SECRETARY—J. F. MINNOTTE, Minnotte Bros., 1201 House Bldg., Pittsburgh

**PUGET SOUND**
CHAIRMAN—H. HAYNES, Commercial Boiler Wks., 53 W. Lander St., Seattle, Washington
SECRETARY—L. A. BURQUE, Westinghouse Elec. & Mfg. Co., Seattle, Washington

**QUAD CITIES**
CHAIRMAN—A. R. GUSTAFSON, 840 Third Ave., Moline, Illinois
SECRETARY—J. W. SHUGARS, Lincoln Elec. Co., Moline, Illinois

**ROCHESTER, N. Y.** 1st Thurs.
CHAIRMAN—FRED L. PEIFFER, 1029 Lyell Ave., Rochester, N. Y.
SECRETARY—PAUL W. JAMES, Lincoln Electric Co., 17 Lake View Park, Rochester, N. Y.

**SAN FRANCISCO** Last Fri.
CHAIRMAN—H. CHANEY, Bethlehem Steel Co., San Francisco, Calif.
SECRETARY—J. G. BOLLINGER, Air Reduction Sales, Park & Halleck Sts., Emeryville, Calif.

**SAN JOAQUIN VALLEY**
CHAIRMAN—G. D. ATMORE, 401 Santa Barbara St., Santa Paula, Calif.
SECRETARY—H. S. NIX, Taft Union H. S. & Jr. College, Box 1364, Taft, Calif.

**ST. LOUIS** 2nd Fri.
CHAIRMAN—L. H. DODD, American Inst. of Steel Const., 1405 Paul Brown Bldg., St. Louis, Mo.
SECRETARY—M. B. SCIOLETICH, Combustion Engrg. Co., Heine Boiler Div., St. Louis, Mo.

**SOUTH TEXAS**
CHAIRMAN—B. W. FARQUHAR, Gulf Oil Corp., Port Arthur, Texas
SECRETARY—T. D. KETCHBAW, Industrial Welding & Testing Lab., Houston, Texas

**TULSA, OKLAHOMA**
CHAIRMAN—F. A. HOFFMAN, Tulsa Boiler & Mach. Co., Tulsa, Okla.
SECRETARY—JAMES B. DAVIS, Tulsa Testing Labs., Tulsa, Okla.

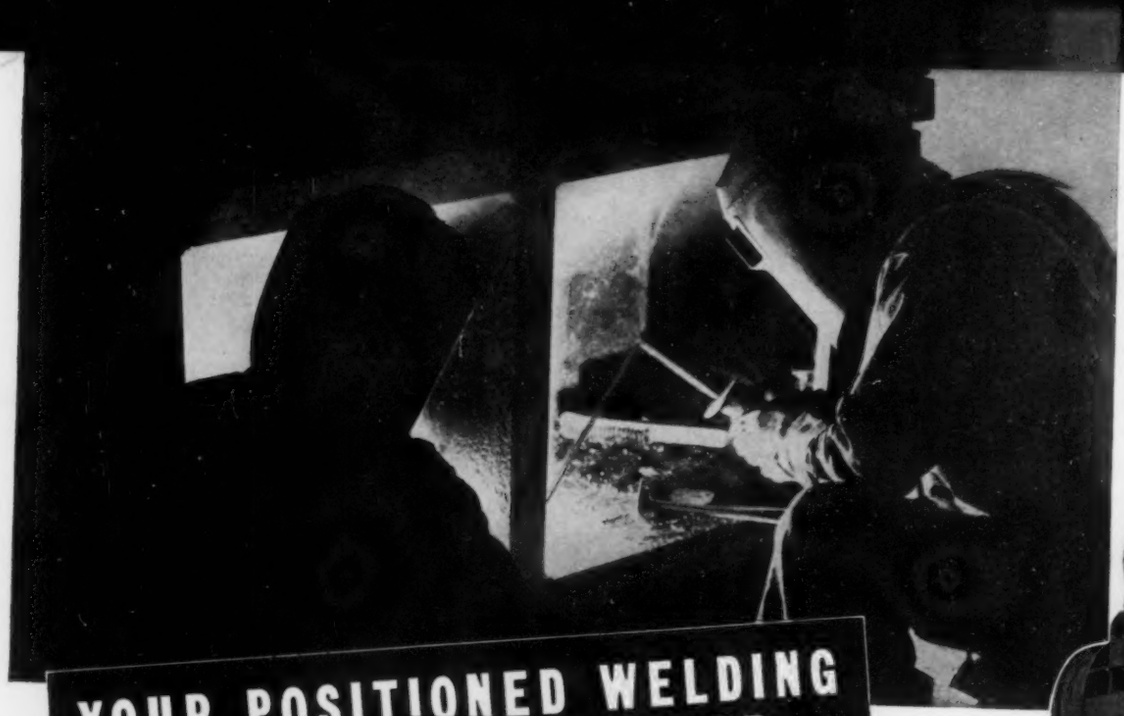
**WASHINGTON, D. C.** 2nd Tues.
CHAIRMAN—C. A. TREXEL, Bureau of Yards and Docks, Navy Department, Washington, D. C.
SECRETARY—E. BROOKER, Bureau Const. and Repair, Navy Bldg., Rm. 3349, Washington, D. C.

**WESTERN NEW YORK** Last Mon.
CHAIRMAN—G. M. TREFTS, III, Farrar & Trefts, Inc., Buffalo, N. Y.
SECRETARY—D. W. PATTERSON, Federal Mach. & Welder Co., Buffalo, N. Y.

**WICHITA, KANSAS**
CHAIRMAN—H. CHRISTOPHER, 1220 Blane St., Wichita, Kans.
SECRETARY-TREAS.—K. O. HOUSER, Kansas Gas & Electric Co., Wichita, Kansas

**YORK—CENTRAL PENNA.**
CHAIRMAN—J. W. HENNESSEY, York Safe & Lock Co., York, Pa.
SECRETARY—C. B. HERRICK, 628 S. Pershing Ave., York, Pa.

**YOUNGSTOWN (OHIO)** 2nd Mon.
CHAIRMAN—E. W. TROSS, United Eng. & Fdy. Co., Youngstown, Ohio
SECRETARY-TREAS.—C. R. RIGGLE, Ohio Edison Co., Youngstown, Ohio



Type FHP welds stan
gaff in equipment
these ingot stripping
made by Shaw-Box
& Hoist Co., Muskegon,

# YOUR POSITIONED WELDING WILL GO EVEN FASTER with Murex TYPE FHP

## THE HIGH SPEED ELECTRODE FOR DOWNHAND FILLETS, DEEP GROOVE WELDING AND COVER BEADS

Easy to use at high amperages, with either A.C. or D.C. current, this recently developed electrode assures more rapid, more economical welding. Its slag is readily controlled and removes freely so that cleaning time is cut to a minimum and costs are reduced appreciably on heavy work where multi-layer welding is required. At the same time, little spatter is produced, weld surfaces are exceptionally smooth, neat and good-looking concave fillets and cover beads are the result.

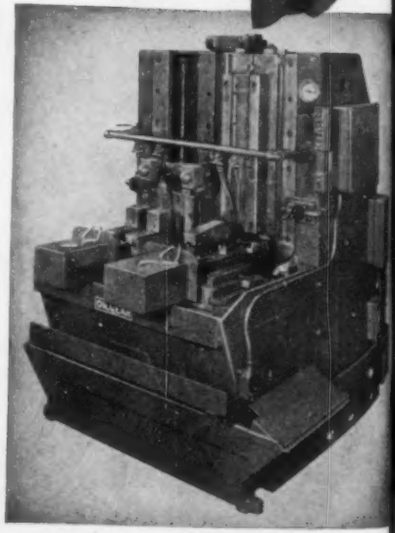
Weld metal deposited by Murex Type FHP is perfectly sound under X-ray examination. Physical properties of welds are well above the various requirements for pressure vessels and other code work.

Write for full particulars and ask to have a Murex engineer call and show you what Type FHP can do on your production welding.

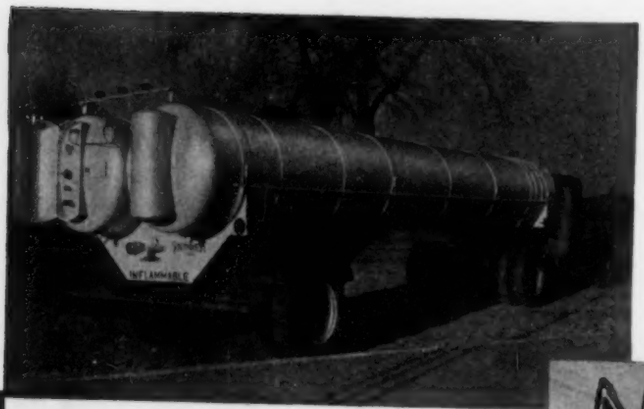
**METAL & THERMIT CORPORATION, 120 BROADWAY, NEW YORK, N. Y.**

Albany • Chicago • Pittsburgh • So. San Francisco • Toronto

*"Murex Electrodes—Thermit Welding—Thermit Metals & Alloys."*



Oilgear Company, Milwaukee, builds well-design
handsome machines; insists upon clean, neat w
like those assured by Type FHP



Welders qualify readily with Type FHP for code welded work like the building of this butane transport tank, made by Southwest Factory, Oklahoma City.

*Investigate Thermit Welding, too—in use since 1902 for heavy repair work, crankshafts, etc.*

MUREX HEAVY COATED Electrodes

A COMPLETE LINE FOR EVERY WELDING APPLICATION